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THE
PROCEEDINGS AND TRANSACTIONS
OF THE
Nova Scotian Institute of Science
HALIFAX, NOVA SCOTIA.

VOLUME XIV
PART I
SESSION OF 1914-1915



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THE attention of members of the Institute is directed to the following recommendations of the British Association Committee on Zoological Bibliography and Publications:—

“That authors’ separate copies should not be distributed privately before the paper has been published in the regular manner.

“That it is desirable to express the subject of one’s paper in its title, while keeping the title as concise as possible.

“That new species should be properly diagnosed and figured when possible.

“That new names should not be proposed in irrelevant footnotes, or anonymous paragraphs.

“That references to previous publications should be made fully and correctly, if possible in accordance with one of the recognized sets of rules of quotations, such as that recently adopted by the French Zoological Society.”

PROCEEDINGS
OF THE
Nova Scotian Institute of Science.

SESSION OF 1914-15.

(VOLUME XIV, PART 1.)

ANNUAL BUSINESS MEETING.

*Civil Engineering Lecture Room, Technical College, Halifax.
21st October, 1914.*

THE PRESIDENT, DONALD M. FERGUSSON, F. C. S., in the chair.

Other members present: DR. A. H. MACKAY, PROF. E. MACKAY, DR. D. FRASER HARRIS, M. BOWMAN, PROF. H. L. BRONSON, PROF. D. S. MCINTOSH, W. MCKERRON, and H. PIERS.

PRESIDENTIAL ADDRESS: (1) Review of the Institute's Work during the Year, (2) Remarks on Valency, (3) General Remarks.—By DONALD M. FERGUSSON, F. C. S.

It is the duty of your president at the annual meeting to speak of members deceased. That, on this occasion, is unnecessary, for, so far as I know, we have suffered no loss by death this session.

Review of Year's Work.

During the year we have had ten papers presented at our meetings, and the subject matter contained contributions in the botanical, chemical, physical, geological and physiological sciences, so that the papers read, though not above our average in number, were varied and represented different fields of research; and I may say that all the papers embody the results of much patient work and are valuable stepping stones in the path of scientific progress.

The paper that evoked the most animated discussion was that of Dr. Fraser Harris on "Coloured Thinking." Much of our recent work has been in the physical sciences, and this departure into mental science met with a hearty welcome.

Of especial practical value to the Province is the series of analyses of Nova Scotian soils contributed by Prof. Harlow. Last year we had a paper from Prof. McIntosh on the geology of the contact zone at the North West Arm; this year Mr. Vickery gives us the analysis of the contact rock locally known as ironstone. This term is somewhat of a misnomer, as "ironstone" is usually applied to an impure iron ore, but the term is used locally on account either of hardness or of the colour of the weathered rock. To contact-metamorphosed rock the general term hornstone or hornfels has been applied. We should have for this local rock of commercial utility some name for common use that would be lithologically correct.

I cannot refer to all the year's work, but I would mention the paper by Mr. J. H. L. Johnstone "On the Electrical Properties of Acetic Acid in the Solid and Liquid Phases." This, following one last year by the same author on the "Conductivity of Ice" shews one trend of present chemical research.

Remarks on Valency.

For many years past our Institute, like other scientific societies, has received papers on measurements of the dis-

sociation of various electrolytes. This field has been well explored, and the dissociation constants of nearly all electrolytes in water solution are known. Much attention is now being given to solvents other than water, and to organic substances, and, as in these papers, to matter in the solid state.

The general acceptance of Arrhenius' theory of electrolytic dissociation has led to our text books of inorganic chemistry and analyses being re-written in ionic terms. According to this, when a molecule of an electrolyte like NaCl is dissociated in solution we have a positive Na ion and a negative Cl ion. A number of years ago Sir J. J. Thomson, in his hypothesis of the electrical nature of matter, suggested that valency and cause of chemical combination consisted in the transfer of electrons between the reacting atoms. On this basis we have as positive atom one which has lost one or more electrons, and as negative atom one which has gained one or more electrons, the valency of the atom depending on the number of electrons transferred. The valency question is one of the fundamental problems of chemistry and the electronic theory has in many forms been applied as a solution. Electrolytic dissociation tells us nothing of the solid state or the gaseous. In dissociation we find H as a positive ion and Cl as a negative. What is the state of the atoms in the electrically neutral molecule of Cl_2 ? In the majority of reactions there seems to be no difference between the two halves of the molecule, but some evidence has been found that the Cl atom may act positively. On the assumption that the diatomic gas molecule consists of one atom positive and the other negative, we have theories of valency, one of which applied to the formula of the benzene ring I shew on the blackboard. Any conception of valency must pass the test of the benzene ring and explain certain peculiarities in the formation of ortho, meta, and para compounds.

In general terms of the electronic theory, the loss of electrons corresponds to oxidation, and a gain of electrons

to reduction. Many reactions are classed as oxidizing without reference to oxygen, and the term "adduction" has been proposed as the opposite to reduction: adduction means the adding of positive charges, and reduction the withdrawal of the same.

Many different electronic hypotheses have been put forward, some not involving transfer of electrons; but the final solution will come from the physicists who gave us the electron. Sir J. J. Thomson, who at one time stated that atoms of one and the same kind may be positive and negative and combine to form a diatomic molecule, in his recent work on Positive Rays, considers that for a union of atoms it is not necessary that one be positive and the other negative, but that a displacement of positive and negative electricity in each atom takes place.

It has recently been shown that if electrons are transferred in oxidation and reduction they are not the same as the beta particles evolved in radioactive changes.

Within this last two years there has been discovered a valuable method of exploring into the region of molecules and atoms. I refer to the discovery of reflection of X-rays from crystal surfaces. Interesting results are being given and, though one cannot anticipate the final outcome, we may soon have established the structure of the atom and the solution of the valency problem. Recent theories give us an atom consisting of a central positive nucleus surrounded by negative electrons. The central nucleus may not all consist of positive charges, but the net positive charge gives an atomic number corresponding to the place occupied by the element in the periodic table. In fact we are promised a periodic table containing all possible elements.

General Remarks.

As a scientific society we cannot but regret that the present war means great curtailment of research, especially on the

continent of Europe. It is hard to say what it will mean having supplies from Germany cut off, for from that country alone have come many of our necessary chemicals. On this continent it is evident that research is increasing in quantity and quality, coming not only from the universities but from governmental and endowed research laboratories and from those of private corporations, such as the General Electric Co., from the research laboratory of which I noticed recently a publication of which one of our life members was a co-author.

You will have reports presented to you from our Librarian and Treasurer, and from these you will see that we may have serious financial difficulties ahead of us. We must endeavor, however, to continue publishing the Transactions, not only for the sake of the Institute and the work of our members, but to act (as we have acted in the past) as the stimulus to scientific work in this Province by publishing the first research paper of many a student, who, receiving encouragement in the atmosphere of the Institute, leaves to make research his life work in the larger world of opportunity outside our shores.

The Treasurer, M. BOWMAN, presented his annual report, showing that the receipts for the year ending 21st October, 1914, were \$1,742.28; the expenditures, \$1,588.28; the balance in current account, \$154.00; the reserve fund, \$311.90; and the permanent endowment fund, \$1,000, the latter being now invested in Maritime Telephone Co. 6 per cent. bonds. The report, having been audited, was received and adopted.

DR. A. H. MACKAY reported that he had interviewed the Government, and urged the restoration of the money grant which had been received by the society for many years, and he felt there was a disposition to assist in some way.

The Librarian's report was presented by H. PIERS, showing that 1,766 books and pamphlets had been received by the Institute through its exchange list during the year 1913;

and 1,424 during the past nine months of the present year, 1914, viz. January to September inclusive. The total number of books and pamphlets received by the Provincial Science Library (with which that of the Institute is incorporated) during the year 1913, was 2,928. The total number in the Science Library on 31st December, 1913, was 51,810. Of these, 37,614 (about 72 per cent.) belong to the Institute, and 14,196 to the Science Library proper. Four hundred books were borrowed, besides those consulted in the library. No binding or direct purchasing has been done during the year. The report was received and adopted.

The following gentlemen were elected officers for the ensuing year (1914-15):

President,—DONALD MACEachern FERGUSSON, F. C. S.,
ex officio F. R. M. S.

1st Vice-President,—PROFESSOR DAVID FRASER HARRIS,
M. D., C. M., D. Sc., F. R. S. E.

2nd Vice-President,—PRESIDENT ARTHUR STANLEY MAC-
KENZIE, PH.D., F. R. S. C.

Treasurer,—MAYNARD BOWMAN, B. A.

Corresponding Secretary,—PROFESSOR EBENEZER MACKAY,
PH. D.

Recording Secretary and Librarian,—HARRY PIERS.

Councillors without office,—ALEXANDER HOWARD MacKAY,
LL. D., F. R. S. C.; PROFESSOR CLARENCE L. MOORE,
M. A., F. R. S. C.; ALEXANDER McKAY, M. A.;
PROFESSOR DONALD SUTHERLAND McINTOSH, M. Sc.;
CARLETON BELL NICKERSON, M. A.; PROFESSOR
HOWARD LOGAN BRONSON, PH. D.; and WILLIAM
HARROP HATTIE, M. D.

Auditors,—WATSON LENLEY BISHOP and WILLIAM McKERRON.

On motion, the PRESIDENT, the two VICE-PRESIDENTS, PROF. BRONSON, PROF. SEXTON, and DR. HATTIE were appointed a committee to interview the Government in regard to the restoration of the financial grant to the Institute.

FIRST ORDINARY MEETING.

*Civil Engineering Lecture Room, N. S. Technical College,
Halifax, N. S.; 9th November, 1914.*

THE PRESIDENT, D. M. FERGUSON, in the chair.

GEORGE H. HENDERSON, B. A., B. Sc., instructor in physics, Dalhousie University, Halifax, read a paper on "The Distribution of the Active Deposit of Thorium in an Electric Field." (See Transactions, page 1). The subject was discussed by the PRESIDENT, DR. A. S. MACKENZIE, DR. BRONSON, and DR. E. MACKAY.

SECOND ORDINARY MEETING.

*Civil Engineering Lecture Room, N. S. Technical College,
Halifax, N. S.; 14th December, 1914.*

THE PRESIDENT, D. M. FERGUSON, in the chair.

It was reported that PROFESSOR ALFRED G. HATCHER and LORNE N. RICHARDSON, instructor in physics and mathematics, both of the Royal Naval College of Canada, H. M. Dockyard, Halifax, had been duly elected ordinary members on the 9th inst.

PROFESSOR DAVID FRASER HARRIS, M. D., C. M., D. Sc., F. R. S. E., Dalhousie University, Halifax, read a paper entitled, "Neuro-muscular Rhythms and the Tremor of Tonus." The subject was discussed by the PRESIDENT, DR. A. H. MACKAY, DR. BRONSON, PRESIDENT MACKENZIE, and DR. E. MACKAY.

THIRD ORDINARY MEETING.

*Civil Engineering Lecture Room, N. S. Technical College,
Halifax, N. S., 11th January, 1915.*

THE PRESIDENT, D. M. FERGUSON, in the chair.

HERBERT BRADFORD VICKERY, Dalhousie University, Halifax, read a paper entitled, "An Investigation of the 'Chromate Method' of Separating the Alkaline Earths." (See Transactions, page 30). The subject was discussed by the PRESIDENT, DR. E. MACKAY, C. B. NICKERSON, C. L. MCCALLUM, and DR. FRASER HARRIS. A vote of thanks was presented to MR. VICKERY.

FOURTH ORDINARY MEETING.

*Civil Engineering Lecture Room, N. S. Technical College,
Halifax, N. S., 15th March, 1915.*

THE FIRST VICE-PRESIDENT, DR. D. FRASER HARRIS, in the chair.

PROFESSOR HOWARD LOGAN BRONSON, PH. D., Dalhousie University, Halifax, read a paper entitled, "A Physical Measurement of X-Rays," (See Transactions, page 17). The subject was discussed by DR. A. S. MACKENZIE, DR. A. H. MACKAY, DR. FRASER HARRIS, and others.

FIFTH ORDINARY MEETING.

*Civil Engineering Lecture Room, N. S. Technical College,
Halifax, N. S., 12th April, 1915.*

THE PRESIDENT, D. M. FERGUSON, in the chair.

PROFESSOR DONALD S. MCINTOSH, M. SC., Dalhousie University, Halifax, read a paper entitled, "Notes on an Abnormal Wave Occurrence on the Northern Cape Breton

Coast in June, 1914." (See Transactions, page 41). The subject was discussed by the PRESIDENT, DR. A. S. MACKENZIE, DR. H. L. BRONSON, DR. E. MACKAY, H. PIERS, and others.

A paper by JOSEPH PERRIN, MacNab's Island, Halifax, entitled, "Additions to the Catalogue of Butterflies and Moths collected in the Neighbourhood of Halifax, etc.," was read by title, and a vote of thanks passed to the writer.

SIXTH ORDINARY MEETING.

*Civil Engineering Lecture Room, N. S. Technical College,
Halifax, N. S., 10th May, 1915.*

THE PRESIDENT, D. M. FERGUSON, in the chair.

PROFESSOR D. FRASER HARRIS, M. D., D. SC., F. R. S. E., Dalhousie University, Halifax, read a paper entitled, "Accidental Electrical Stimulation of the Human Retina *in situ*." (See Transactions, page 47). The subject was discussed by PROF. E. MACKAY, C. B. NICKERSON, DR. FRANK WOODBURY, DR. F. W. RYAN, DR. A. H. MACKAY, and the PRESIDENT.

Dr. A. H. MACKAY presented a paper on "Phenological Observations in Nova Scotia, 1914." (See Transactions, page 57). The subject was discussed by H. PIERS.

HARRY PIERS,

Recording Secretary.

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1914-1915.

THE DISTRIBUTION OF THE ACTIVE DEPOSIT OF THORIUM
IN AN ELECTRIC FIELD.—BY G. H. HENDERSON, B.A.,
B. Sc., *Instructor in Physics*, Dalhousie University,*
Halifax.

(Read November 9th, 1914.)

The problem of the distribution of the active deposits of radio-active substances in electric fields is an old one and was early investigated by Rutherford¹, Russ², Kennedy³, and others. In much of this early work no attempt at precision was made and a considerable part of it was rendered of doubtful value by faulty experimental arrangements. The problem in the case of radium was more recently taken up by Wellisch and Bronson⁴ and by Wellisch⁵ and in the case of actinium by Walmsley.⁶

It was felt that a similar investigation of the active deposit of thorium was timely and might throw further light on the mechanism producing the charged condition of the active deposit particles and on the conditions which affect their distribution in electric fields.

* Contributions from the Science Laboratories of Dalhousie University—[Physics].

1. Rutherford, *Phil. Mag.*, Feb. 1900, Jan. 1903.

2. Russ, *Phil. Mag.*, June, 1908.

3. Kennedy, *Phil. Mag.*, Nov. 1909.

4. Wellisch and Bronson, *Am. Journ. Sci.* XXXIII, May 1912.

5. Wellisch, *Am. Journ. Sci.* XXXVI., Oct. 1913.

6. Walmsley, *Phil. Mag.*, Sept. 1913.

Practically all the testing vessels used in the above researches were cylindrical cases having an insulated rod in the centre. These vessels have the disadvantages of having an ununiform field and of presenting surfaces of unequal area to the active deposits. Therefore it was decided to try vessels having parallel plate electrodes. It is important that the testing vessel be so constructed that the active deposit particles or "rest atoms" would be deposited only on the electrodes and none on other parts of the vessel where they would remain unmeasured. To accomplish this several types of vessels were used, only two of which need be described. The construction of the first type is shown in Figs. 1 and 2. The electrodes were cut out of zinc as shown in Fig. 1. The flaps

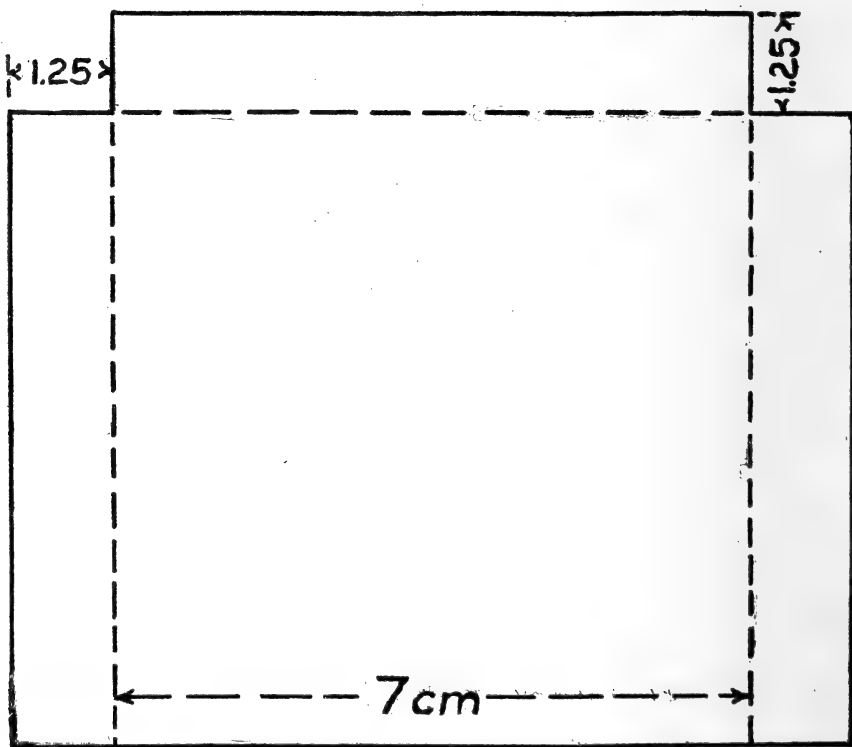


FIG. 1.

were folded over on the dotted lines forming a shallow box one end of which was missing. Two of these electrodes, their hollow sides facing one another, were slipped open ends downwards into a wooden case. The electrodes and case set up ready for an exposure are shown in cross section in Fig. 2. A A are the electrodes, B B is the case, C C are wooden pegs fixed in the sides of the case to separate the electrodes. The edges of these were .3 cm. apart making the main parts of the plates 2.8 cm. apart. D is the bottom on which the case rests. It projects up a short distance inside B. The top of this projection is slightly hollowed out, forming a shallow trough G on which lay the thorium hydroxide, which was used as source of the thorium emanation. The plates rest on the rim of the trough. E E are leads and F is the cover of the box. All the wooden parts of the apparatus were boiled in paraffin to secure good insulation. Owing to the long period of thorium B (10.6 hours) the experiments necessarily proceeded with some slowness. Exposures varying from 6 to 36 hours were made, about 24 hours being usual. The plates were then removed from the vessel and their activities measured. As the decay curve for thorium active deposit of long exposure is practically flat for the first half hour, no correction for decay during the time of measurement was needed, and even with exposures as short as 6 hours only a small correction was required. This has been applied when necessary. The activity of the plates was measured by an α ray electroscope, similar to that described by Rutherford.¹ The earthed case of the electroscope was surrounded by a second case of cardboard with glass windows, to protect the instrument from extraneous effects of air currents and temperature. A water filter was also used to eliminate the heating effect of the lamp. The gold leaf was charged to 200 volts and its rate of fall was observed through a tele-microscope. The time required to pass over a certain

1. Rutherford, Radio-Active Substances, p. 90, fig. 12.

4 DISTRIBUTION OF THE ACTIVE DEPOSIT OF

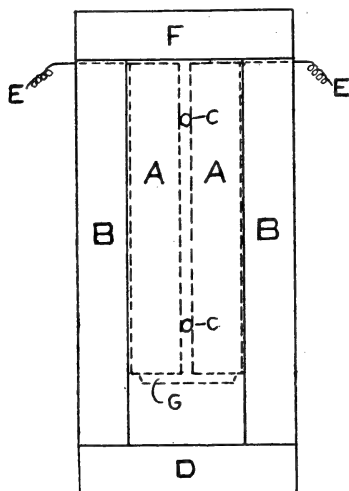


FIG. 2.

number of scale divisions was measured with a stop watch. This range of scale was kept the same for any given experiment. A correction for the natural leak of the instrument was always applied. This correction was usually a small fraction of the anode activity.

A typical set of measurements is given below:

Box 8 Plates 10 Voltage = 40.4. Dry air over H_2SO_4 . Set up 2:15 P.M. Oct. 25, 1914.

Plates removed 9:01 A.M., Oct. 26, 1914.

Plates.	Period.	Divisions.	Time.	Rate.	Cor. Rate.
10—	25.6''	60—50	9:05 A.M.	.3906	.3880
10+	9' 55.0''	60—50	9:16 A.M.	.0168	.0142

Percentage cathode activity = 96.5.

The first line gives the conditions under which the exposure took place. The first column shows the electrode measured. The column marked "Period" gives the time taken by the gold leaf in moving over the scale divisions indicated in the next column. The column marked "Time" shows the time of conclusion of each measurement. The next column shows the rate of fall of the needle, while the last column shows this rate corrected for natural leak, and the decay when necessary. The corrected rate is a measure of the activity of the plate. The percentage cathode activity

$$= \frac{\text{Cathode activity} \times 100.}{\text{Cathode activity} + \text{anode activity}}.$$

The error in the values of the percentage cathode activity was mainly that made in measuring the anode activity. This error was seldom as much as 2 per cent. The readings were usually repeated several times and the mean taken.

An objection to these vessels might be raised, namely, that the plates are very close together at the edges, and that this distorted field was the determining part of the field. That this was not the case was shown as follows:

An exposure was taken as usual. The activities of the plates were measured as usual. Then the plates were covered with a zinc screen neatly covering the whole of the plates except a part in the flat portion of the plate where the screen was cut out, and which could expose a portion of either the top or bottom half of the plate. The size of this opening was 5.8 x 2.8 cm.

The activities of the plates were then measured with the lower and upper portions exposed. The results follow: Box 6. Plates 15. Volts 2.1. Laboratory air.

Whole Plates.

Activity on cathode = .604.*

“ “ anode = .294.

Percentage cathode activity = 67.3

Total activity on two plates = .89

Lower Portion Exposed.

Activity on cathode = .228.

“ “ anode = .114.

Percentage cathode activity = 66.7

Total activity = .33.

Upper Portion Exposed.

Activity on cathode = .157.

“ “ anode = .076.

Percentage cathode activity = 67.3.

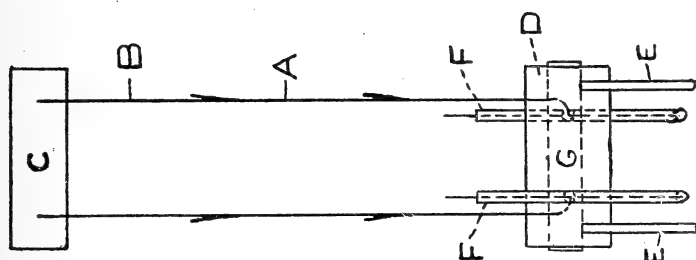
Total activity = .23.

The size of the opening was about 22% of the total area of the plates including the sides. The relative total activities would show that the density of active deposit on the edges was less than that on the flat portion of the plates.

In general, fairly satisfactory results were obtained with this type of vessel. However, some discordant results were obtained which were hard to explain, but it was thought that the large amount of insulating material surrounding the electrodes might be the cause of these irregularities.

A second type of vessel was therefore constructed which avoided this difficulty as far as possible. End and side views of this vessel are shown in Fig. 3. The plates, which were of zinc, were made on the guard ring principle. The main plates, A, 5.8 cm. square, were slipped into place and held there by short lugs which engaged with clips on the back of the guard plate, B. The guard plates were 13 cm. square with an opening of 5.9 cm. square in the centre to receive the

*Arbitrary units.



END VIEW—FIG. 3.

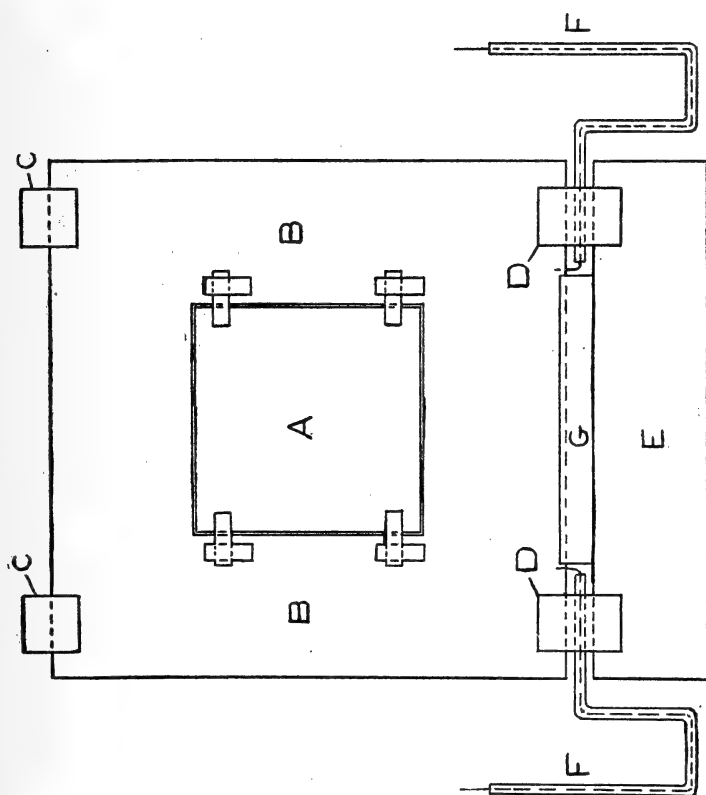


FIG. 3.

SIDE VIEW—FIG. 3.

plates, A. The guard plates were kept 3.0 cm. apart by wooden blocks C and D at top, and bottom. The latter were supported on glass legs, E. The apparatus was set in a shallow glass dish and was covered by a rectangular glass jar. Control of the atmospheric conditions of the exposure was obtained by sealing the bell jar with a layer of liquid in the shallow glass dish. To secure dry air, concentrated sulphuric acid was the liquid used. In experiments on the effect of water vapor, water replaced the acid. For other gases a mercury seal was used to keep the desired vapor in the vessel. The thorium hydroxide was placed in a shallow wooden box G, under the plates and supported by the glass legs E. Connections with the plates were made by wires passing through glass tubes, F F, bent to pass under the bell jar through the liquid.

A number of advantages can be claimed for this type of vessel in studying the distribution of the active deposits.

The field is practically uniform over the plates A, any distortion of the field at the edges being eliminated by the guard plate.

No insulating material is near the electrodes.

Equal areas of electrodes are presented to the active deposit.

The activities of the two plates are measured under identically the same conditions, in the most simple manner, by a gold leaf electroscope.

Good control of gaseous conditions can be secured.

A series of observations was made with applied potentials varying from 6 to 12,000 volts. The highest voltage was obtained by the use of a Wimshurst machine run by an electric motor. The length of the spark gap was .35 cm. and the diameters of the knobs 3.0 cm. and 1.5 cm., giving an estimated voltage of 12,000. The air was dried by standing over concentrated sulphuric acid. The results obtained are shown in Table 1 and plotted in curve A, Fig. 4.

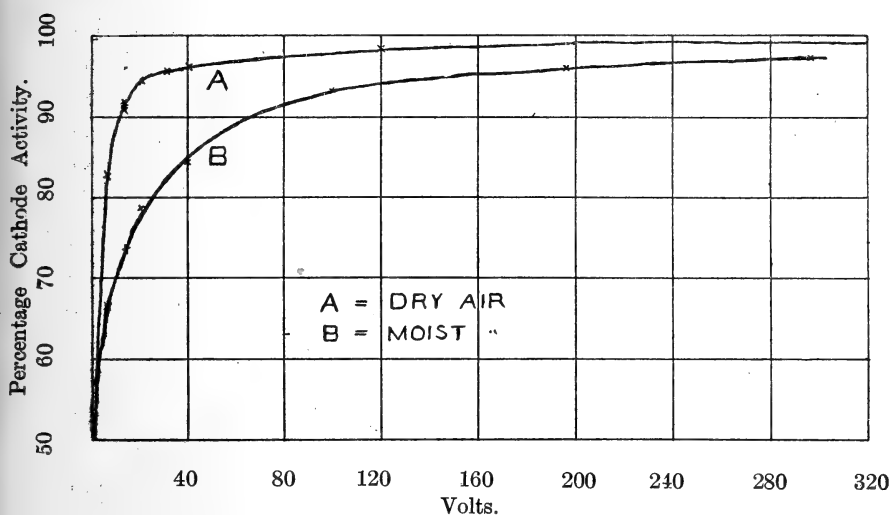


FIG. 4.

TABLE 1.

Volts.	Percentage cathode activity.
6.4	82.9
14.1	91.4
14.0	92.0
14.1	91.0
20.4	94.7
32.0	95.9
40.4	96.5
120.0	98.6
12,000.0	99.8

It will be seen that this curve has the general shape of the ionization saturation curve. The percentage cathode activity at 12,000 volts is the mean of three observations, in one of which the activity of the anode measured less than the natural leak. As this value differs from 100 by less than the observational error, there is no evidence to show that initially any fraction of the rest atoms is neutral. It must be understood that the use of the word initially, as in this instance,

refers only to a time after that infinitesimal fraction of a second during which recoil is operative. This curve differs in two respects from that found by Wellisch and Bronson for radium. (1) It reaches approximate saturation at much lower voltages. (2) There seems to be no evidence that any fraction of the rest atoms is initially unchanged. Experiments showed that the dimensions and form of the testing vessel and the concentration of the rest atoms are largely responsible for (1), and that approximate saturation in air is reached with about the same potential gradient for thorium as for radium.

Thus the evidence in the case of dry air would indicate that initially all the rest atoms of thorium are positively charged and that all the activity on the anode at low voltages is due to these rest atoms losing their charge by recombination with negative ions in the air.

It was found by Wellisch and Bronson that 10.4 per cent. of radium rest atoms were initially uncharged in dry air. Experiments were made to test whether this difference between radium and thorium was due to the type of vessel used.

The percentage cathode activity in the case of radium was measured with parallel plate vessels. The source of radium emanation used was a layer of radium chloride deposited on a sheet of aluminum. Preliminary measurements with the first type of vessel described, showed that this fraction was of the same order as that found by Wellisch and Bronson for cylindrical vessels. Later the experiment was repeated using the second type of vessel and a potential of about 12,000 volts supplied by the Wimshurst machine. The percentage cathode activity was found to be 5.2. This would make the total fraction unaffected by the electric field 10.4 per cent. in good agreement with the latest value (11.8) found by Wellisch¹.

1. Wellisch, Phil. Mag. Oct. 1914.

The distribution of the thorium active deposit was also measured in cylindrical vessels. The vessels were of the usual type. Air dried by passing over phosphorus pentoxide was passed over thorium hydroxide, and then through the testing vessel at a slow enough rate so that practically all the emanation would decay in the vessel. The activities of the rod and case, the rod being used as cathode, were measured by means of a Dolezalek electrometer. The activity of the rod was measured in a cylindrical vessel, free from active deposit, of the same dimensions as the anode case; while the latter was tested with a clean rod similar in dimensions to that used as cathode. The same general results were obtained as with the parallel plate vessels although the voltage necessary to bring over a given fraction of the rest atoms on to the cathode was higher owing to the difference in shape of the vessels. A similar rise of percentage cathode activity with voltage was found. With 280 volts (the highest used), the percentage cathode activity was 95.3.

From these experiments it will be seen that parallel plates and cylindrical vessels give concordant results.

To test if the variations between thorium and radium might be due to a surface effect of the electrodes, experiments were made to see if the surface conditions of the electrodes had any effect on the distribution of the rest atoms.

Experiments with copper and lead electrodes gave results similar to those obtained with zinc plates. The state of polish of the electrodes also had no effect on the distribution. These results are in accordance with those found for radium by Wellisch¹ and by Walmsley².

An interesting result found by Godlewski³ might be referred to here. He found that on electrolyzing a solution of actinium, the active deposit was transported to the cathode, only when the cathode plate had previously been used as

1. Wellisch, *Am. Journ. Sci.* Oct. 13.

2. Walmsley *Phil. Mag.* Oct. 14.

3. Godlewski, *Bull. Acad. Sci. de Cracovie*, June 1913.

anode, and hence was electrolytically saturated with hydrogen. To test if a similar effect took place with thorium in air, experiments were made, using as cathodes plates previously used as anodes, and *vice versa*. No effect was detected within the limits of observational error.

It was found by Wellisch and Bronson that in the case of radium a much greater proportion of the rest atoms were uncharged in an atmosphere containing water vapor than in dry air. The effect of water vapor on the distribution of the rest atoms of thorium was accordingly tried. In order to obtain the maximum effect possible with water vapor experiments were made with air saturated with water vapor at room temperatures. This was accomplished by substituting water for the sulphuric acid of the previous experiments so that the plates stood over water. As the temperature of the laboratory varied from day to day the conditions under which the different results were obtained were not identical. The general effect however is seen in table 2, and is plotted in curve B, Fig. 4.

TABLE 2.

Volts.	Percentage cathode activity.
6.4	66.5
14.1	73.7
20.3	78.8
40.0	84.8
99.7	93.4
196.	96.0
313.	97.2

The effect of water vapor is evidently to greatly increase the rate of recombination. The question of its effect on the initial charged condition of the rest atoms will be referred to after the effects of ether vapor have been discussed.

It was found by Wellisch¹ that in an atmosphere of 8 cm. of ether vapor all the radium rest atoms were uncharged. The effect of adding ether vapor to the air was found to be very marked in the case of thorium. The apparatus was placed under a bell jar from which the air was then exhausted. Ether vapor in different quantities was added, air was then allowed to enter till atmospheric pressure was reached. The results obtained are shown in table 3 and graphically in fig. 5. The potential employed was 40 volts and old type vessels were used.

TABLE 3.

Ether added in cm. mercury.	Percentage cathode activity.
0	96.5
3.8	83.8
9.9	68.0
15.7	60.6
37.2 ²	54.5

The effect of different potentials in the case of ether vapor is shown in table 4. The ether vapor was saturated at room temperatures and the results therefore are not strictly comparable. The general effect however is seen. Old type vessels were used.

TABLE 4.

Volts.	Percentage cathode activity.
13.9	51.1
40.0	54.5
292.0	62.3

-
1. Wellisch, Phil. Mag, Oct. 1914.
 2. Estimated, air saturated.

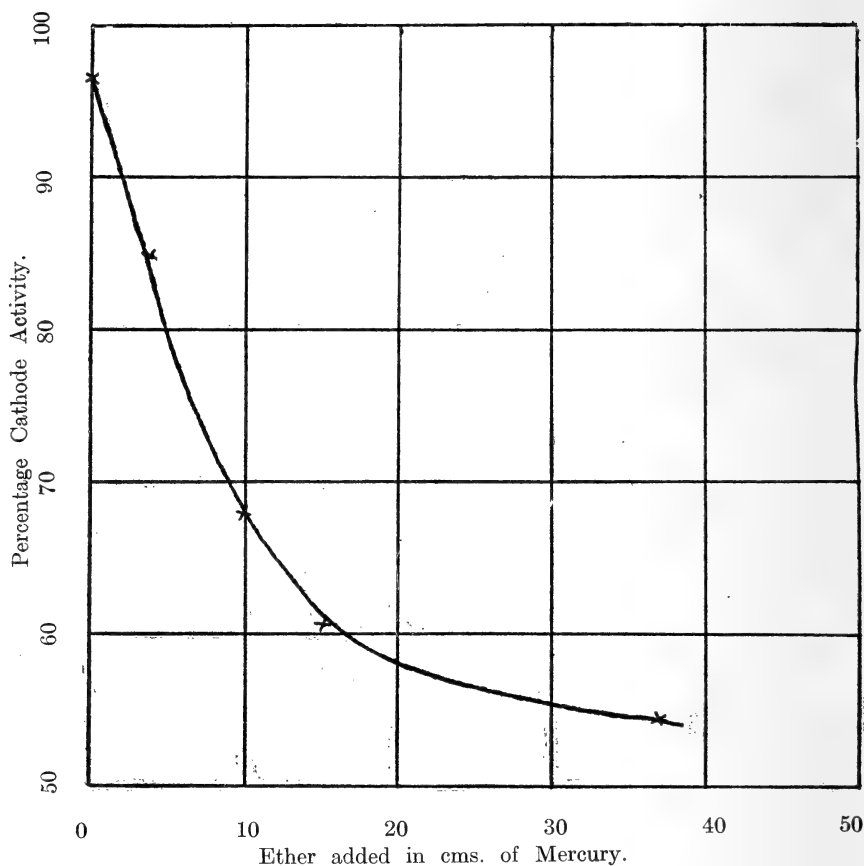


FIG. 5.

Two conclusions are suggested from these tables. 1st. With a given voltage the percentage cathode activity depends on the quantity of ether vapor present. 2nd. There is no evidence that with high potentials a value at all near 100 exists for the percentage cathode activity. This evidence points to the conclusion that part of the rest atoms are initially charged and part uncharged, and that the relative amounts of charged and uncharged rest atoms depend on the relative quantities of ether and air.

To further test this point, the following experiments were tried, the voltage in both cases being 313.

1st. The testing vessel was placed under a bell jar, the air exhausted and 10.2 cm. of ether vapor allowed to enter. Then air was admitted till atmospheric pressure was reached. The percentage cathode activity was 63.8.

2nd. The testing vessel was set up under a bell jar as before and the air exhausted to 0.7 cm. Then 10.2 cm. ether vapor were added and the exposure taken under a total pressure of 10.9 cm. The percentage cathode activity was 50.8.

A similar effect in the case of water vapor was sought. The bell jar containing a dish of water in addition to the testing vessel was exhausted to 1.6 cm. and an exposure taken using a potential of 312 volts. Owing to leakage the final pressure was 2.3 cm. The percentage cathode activity was 79.9. The exact proportions of water vapor and air in the bell jar were hard to determine but at least half the pressure was due to water vapor.

At such low pressures the percentage of the active deposit on the anode is increased due to recoil of the rest atoms. In order to test whether recoil could wholly account for the low value of the percentage cathode activity with water vapor, an exposure was taken using dry air at initial and final pressures of 1.35 and 1.55 cm. respectively. The percentage cathode activity was 94.6.

Thus we see that in an atmosphere of pure ether all the rest atoms are uncharged, which further strengthens the conclusions drawn from tables 3 and 4. The results with water vapor point towards similar conclusions, notwithstanding the experimental difficulty; the pressure of the water vapor being necessarily small, and there being a considerable fraction of air present.

Experiments tried in atmospheres of various other substances gave no evidence that in any pure atmosphere the

rest atoms were initially partly charged and partly uncharged. In this respect thorium seems to differ from radium. It was shown by Wellisch that, in hydrogen and in carbon dioxide, the rest atoms of the latter are partly charged and partly uncharged. The case of air is peculiar as it is a mixture. Further investigation along these lines is in progress.

SUMMARY.

A new type of vessel for this kind of work has been developed and its advantages noted.

It has been shown that in dry air all the thorium rest atoms are initially positively charged.

In pure ether vapor all the thorium rest atoms are initially uncharged and in a mixture of ether vapor and air the charged condition of the rest atoms depends on the relative amounts of ether vapor and air present. A similar state of affairs appears to be true with water vapor.

In conclusion I wish to express my best thanks to Dr. Bronson, who suggested the work and without whose continued interest this work would not have been possible.

A PHYSICAL MEASUREMENT OF X-RAYS.—BY HOWARD L. BRONSON, PH. D., *Professor of Physics in Dalhousie University.*

(Read 15 March 1915)

INTRODUCTION.

The use of Roentgen rays by the medical profession has increased very rapidly during the past few years, but, as yet, no method of measurement has been generally accepted. At present a large variety of instruments, methods, and units are used. For adding another method to the number already too large, the writer finds his justification in the fact that he not only employs a physical measurement of some accuracy, but also that it is not too complicated for practical use. All the physical principles used are old and have been used before.

The problem was suggested to the writer several years ago by Dr. G. P. Girdwood of Montreal, but a satisfactory galvanometer was not available at that time. The galvanometer needed for this work should be of the D'Arsonval type with a sensitiveness of at least 5×10^{-10} amperes per scale division, but should not be delicate mechanically. The resistance of the galvanometer is unimportant, but it should have as short a period as possible and at the same time be critically damped on open circuit. Dr. Edward Weston has recently developed an instrument which just meets these requirements. One of these he very kindly loaned for this work. The other things essential for satisfactorily carrying out this work were supplied by Dr. W. H. Eagar of Halifax, who was kind enough to place his office and most excellent X-Ray equipment at my disposal. In addition to this, experiments were carried on at Dalhousie University and at the Nova Scotia Technical College with the apparatus belonging to these institutions.

Roentgen rays are commonly used for two distinct purposes:

(1) For diagnostic work by means of fluoroscope and radiograph;

(2) For their therapeutic action.

In each case it is important to know both the quantity or intensity and the quality or hardness of the rays furnished by the tube. There are two *general* methods of measurement:

(1) The electric energy delivered to the bulb is measured and it is assumed that all or a constant fraction of this leaves the bulb as X-rays. A recent article by Dr. G. W. Holmes* shows that experience would seem to justify this assumption. This method does not distinguish directly between the quantity and quality of the rays, but the applied potential is taken as a measure of the hardness;

(2) The quantity and quality of the rays themselves may be directly measured; the quality by some form of penetrometer, which involves the comparison of the intensity of illumination of two surfaces; the quantity by the change produced in the color of some substance, such as barium platino-cyanide, in which case a color comparison is involved.

In a few cases the ionization produced in air has been used as a means of measuring the strength of the rays. Except for experimental difficulties, this should be the ideal method as practically all the evidence indicates that the various effects of Roentgen rays are directly related to their ionizing action. A simple direct reading instrument, making use of this principle, has been recently described by Dr. B. Szilard†. For some purposes this instrument should prove very useful, but for others the length of time necessary to get a reading would be objectionable. The instrument is calibrated to give directly the total number of ions formed in 1 c.c. of the air exposed to X-rays during the time of an exposure.

*The American Journal of Roentgenology, May, 1914.

†Archives of the Roentgen Ray, June, 1914.

The writer also makes use of the ionizing action of X-rays, but employs quite a different method for measuring it. He is able in a few seconds to determine with considerable accuracy the intensity and hardness of the rays, as well as the time of exposure necessary to obtain radiographs of proper density, even under very unfavorable conditions.

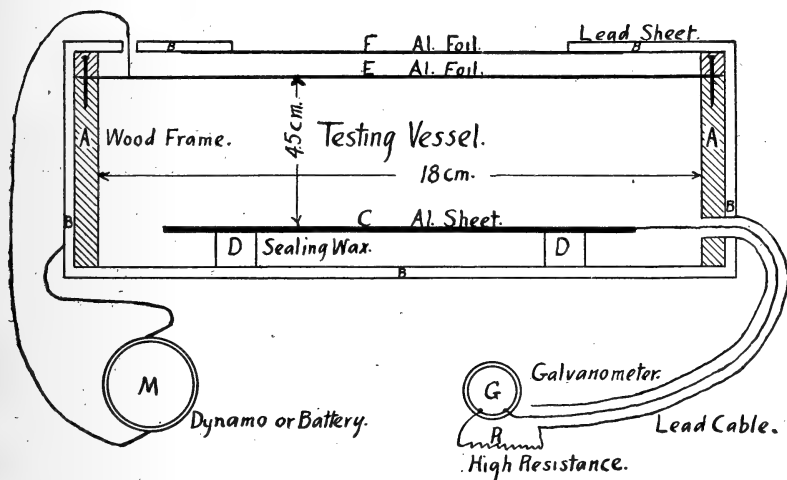


Fig. 1.

APPARATUS.

Figure 1 shows a section of the testing vessel drawn approximately to scale and gives a diagram of connexions. The galvanometer was a Weston Model 89, having a tripod base, and was very easily adjusted by means of an attached spirit level. It was mounted on a window-stool, shelf or mantel according to circumstances, and its deflection was read by means of a lamp and scale. With the scale at a distance of one meter, it gave a deflection of 1mm. for a current of 3×10^{-10} amperes. The high resistance R , of about 10^6 ohms, was made by a pencil line on ground glass and was used merely to protect the galvanometer. The resistance of

the testing vessel was so high in comparison that R can be neglected in the calculations. M may be any fairly steady source of potential, high enough to produce practical saturation. It should be at least 100 volts and was about 200 in the present experiments. Sometimes it was obtained from storage cells and sometimes from a small 220 volt D. C. motor used as a dynamo and driven by a small A. C. motor.

One potential terminal was connected to the outside lead covering of the testing vessel and the other to the insulated aluminum foil E . The foil F was used to protect E from possible electrostatic action, and both were too thin to produce appreciable absorption of the X-rays. The aluminum plate C was very carefully insulated on sealing wax so that the galvanometer would be sure to measure the current due to the X-ray ionization between the plates E and C . The wire leading from C to the galvanometer was a small lead covered cable. The lead cover was connected through the high resistance R to one terminal of the galvanometer and to the lead case of the testing vessel, thus completing the circuit.

The X-ray tube was mounted at any desired distance directly above the opening F . The size of the bundle of rays entering the vessel was determined by placing on top of the vessel a lead sheet with suitable opening. Six tubes of various makes and construction were used and similar results were obtained with all. The smallest tube was about 13cm. in diameter and had a light platinum target, and the largest was about 18cm. in diameter and had a heavy tungsten target.

The different sources of power used included a large and a small induction coil with both Wehnelt and mechanical interrupters and a high tension transformer and commutator (Waite and Bartlett Mfg. Co.), giving an interrupterless current. The current through the tube was measured by a milliammeter, but the spark gap was the only means at

my disposal of estimating the potential on the tube. In the various experiments the currents used varied from 5 to 0.3 milliamperes and the spark gap from 8 to 18cm.

EXPERIMENTAL METHODS AND RESULTS.

The present investigation may be divided into three distinct parts:

- (1) To discover whether the action of Roentgen rays on a photographic plate is proportional to the ionization in the air near the plate, and thus to be able to determine the proper length of time for an exposure;
- (2) To compare the action of the rays on a Sabouraud pastille with their ionizing action;
- (3) To find an accurate method of comparing the hardness or penetrating power of the rays.

(1)

In order to test the first point the ionization current was measured with some object, for example several sheets of glass, aluminum or lead, covering the opening F of the testing vessel. Then a photographic plate, covered by the same object, was exposed to the action of the rays, produced under the same conditions as before. The X-ray plates used were either Ilford or Wellington, the developer was carefully prepared according to the maker's directions, and great pains was taken to always use the same quantity of fresh developer at the same temperature and to develop for the same length of time.

It was discovered by preliminary experiments that an exposure of 5 sec. gave a satisfactory negative, when the deflection of the galvanometer was 40mm. with a bundle of rays 100 sq. cm. in area. Thereafter the time of exposure of any plate was adjusted to be inversely proportional to the current through the galvanometer, that is, the product of the

time of exposure and the deflection of the galvanometer was always 200.

The procedure in a particular case where six sheets of lead foil, each .026mm. in thickness, was to be the subject radiographed, was as follows: The six sheets of foil were first placed over the opening F, the tube was started up and the galvanometer deflection was 30mm. The foil was then removed from F and a small photographic plate was placed at C. Upon this there were placed, side by side, three strips of lead containing respectively 4, 6 and 8 thicknesses of the above foil. The strips with 4 and 8 thicknesses each were used merely to have some contrast on the negative. The plate was then exposed for $\frac{200}{30} = 7$ sec., with the tube working under as nearly as possible the same conditions as previously.

Over one hundred radiographs were taken as described. Various thicknesses of glass, aluminum and lead were used as the subjects for the radiographs and the rays in the different experiments differed widely in their characteristics, but the negatives showed practically the same photographic action on those portions covered by the materials under examination. Table I gives a record of six plates, all having lead foil for the subject of the radiograph, but taken with rays which were very different for the different plates. The first three were taken with a 17cm. tube having a tungsten target and using an interrupterless current and the last three with a 13cm. tube having a platinum target and operated by a small induction coil and a mechanical interrupter. The density of the negatives appeared to be alike within the limits of accuracy of the various measurements..

TABLE I.

Plate No.	Milliammeter.	Spark Gap.	Lead.	Gal. Defl.	Exposure.
91	1.1	unknown	.104mm.	23	9 sec.
95	4.1	unknown	.208mm.	16	12.5 sec.
96	3.1	unknown	.208mm.	29	7 sec.
10	0.38	18cm	.104mm.	7	29 sec.
10	9.38	18cm	.156mm.	5.5	36 sec.
107	0.50	9cm	.104mm.	5	40 sec.

A comparison of the currents through the tube with the galvanometer deflections, in the cases of 95 and 96 and of 105 and 107, shows how unsafe it is to judge the intensity of the X-rays by the milliammeter alone. In both cases the current through the tube increased, but the galvanometer reading decreased, and the radiographs showed that the desired results were obtained by increasing the time of exposure, as was actually done. We must conclude then that the relative action of Roentgen rays on a photographic plate and in ionizing the air near the plate remains practically constant, however the rays themselves may be altered.

In order to compare the absorbing power of various parts of the body with various thicknesses of lead foil, radiographs of the knee, the thigh and the chest were taken with lead foil of varying thicknesses on the same plates. The results were rather unsatisfactory, because somewhat different results were obtained with rays of different hardness, and in practice it would be better to use aluminum sheet in place of lead foil for this purpose. However, the negatives showed about the same density for the following when the penetration was 8 or 9 Benoist:

Knee joint and 8	thicknesses of foil	each .026mm.
Thigh bone and 10	"	"
Flesh of thigh and 8	"	"
Ribs and 10 or 12	"	"

By making such a comparison once for all, and using aluminum instead of lead, it would be possible in a few seconds by a single reading of the galvanometer, with proper thickness of aluminum over the testing vessel, to determine the time of exposure necessary to obtain a satisfactory radiograph of any part of the body. Of course, this would be of no practical value for powerful installations, where exposures are for only a second or two, but might be of great value where exposures for a considerable time have to be made.

(2)

In order to investigate the second point, a Sabouraud pastille was placed on the aluminum foil at F and exposed, sometimes to the direct action of the X-rays and sometimes with slight aluminum screening. During the time of exposure the deflection of the galvanometer was read at regular intervals. The average of these readings multiplied by the time of exposure and by the galvanometer constant gave the charge that passed through the galvanometer, and this divided by the volume of air ionized and by the number representing the change in color of the pastille, as measured by Dr. Hampson's radiometer, should give a constant K, if the effect on the pastille is proportional to the ionization produced in the testing vessel. The last nine comparisons gave the following values for K: 2.4, 2.6, 2.7, 2.4, 2.5, 2.6, 2.4, 2.4, and 2.6, all multiplied by 10^8 . Thus, we see that this method furnishes an accurate and quick method of testing the therapeutic action of any tube. In these experiments only the interrupterless current was used, but hard and soft tubes were tried with currents varying from 1 to 5 milliamperes.

(3)

Less attention was paid to the measurement of hardness than to the previous parts of the work, but a number of experiments were tried to see how the ionization current

through the testing vessel is changed by various thicknesses of lead or aluminum placed over the opening F, and in each case the hardness was measured by a Benoist penetrometer. Table II shows the nature of the results obtained in a single experiment.

TABLE II.

Hardness.	Sheets of Lead Foil, each .26mm thick.	Gal. Defl.	% of Max. Defl.
9 Benoist	0	178	100
	1	83	47
	2	51	29
	4	25	14
	6	15	8

Table III gives a summary of the results obtained with different tubes of various degrees of hardness. Columns 3 and 4 give the thickness of lead and aluminum necessary to reduce the ionization to half value. Column 5 gives the ratio of the ionization when there are two and when there is only one sheet of lead foil over F, and column 6 gives a similar ratio of the ionization for 4mm and 2mm of aluminum.

TABLE III.

Tube.	Hardness.	3	4	5	6
No. 1.....	9 Benoist	.036mm	4.4mm	62%	73%
No. 2.....	7 Benoist	.....	3.5mm	.....	64%
No. 2.....	6 Benoist	.023mm	.....	45%	.....
No. 2.....	5 Benoist	.018mm	1.7mm	28%	43%
No. 4.....	7 or 8 Benoist	.030mm	3.6mm	55%	68%

In practice it would be much easier and quicker to obtain the hardness of a tube from the data of column 5 or 6 than from 3 or 4. It is a well known fact, which is also clearly shown in Table III, that X-rays become less and

less easily absorbed the more lead they pass through. It is for this reason that the figures in columns 3 and 4 have been made to apply to rays which have already passed through .026mm of lead or 2.0mm of aluminum respectively.

Table III shows that the apparatus is well suited to make comparisons of the hardness of X-rays. It is only necessary to take two readings of the galvanometer, first with one sheet of foil and then with two sheets. The ratio of the readings may then be used as a measure of the hardness. By obtaining foil of the right thickness, it would be possible to arrange a simple scale which would correspond with any of the various penetrometers now in use.

DISCUSSION OF RESULTS.

The experiments above described show how a single instrument may be very simply used to determine both the quantity and quality of the Roentgen rays from any tube, as well as the length of time of exposure needed to produce radiograms of proper density. In each case the ionizing action of the rays is made use of and the measurements are all made with a galvanometer, which avoids the uncertainty and difficulty of comparing the color or the equality of illumination of two surfaces.

The physical explanation would seem to be that the magnitude of the effect produced by the rays on the photographic plate, the pastille and in ionizing the air depends on the energy used up in each case, and that the relative amounts absorbed in the three processes remain practically constant for rays differing widely in their characteristics.

The nature of the apparatus makes it comparatively easy to calculate the number of ions produced per c.c. near the photographic plate during the time of exposure or near the pastille during the time of some definite change in color. Let V = volume of testing vessel exposed to the ionizing action of the rays.

t = time of exposure in seconds of either plate or pastille.

N = total number of ions per c.c. produced in the testing vessel during time t .

e = charge on an ion— 4.7×10^{-10} E. S. units.

k = galvanometer constant— 3.0×10^{-10} amperes per mm. deflection.

d = deflection of galvanometer.

q = charge passing through the galvanometer in time t .

Then $q = NeV$ E. S. units (if there is no recombination).

also $q = kdt$ coulombs

and $NeV = (kdt) 3 \times 10^9$.

In the experiments with the photographic plates, as has been stated, t was so chosen that $dt = 200$, and V was $100 \times 4.5 = 450$ c.c.

$$\therefore N = \frac{3 \times 10^{-10} \times 200 \times 3 \times 10^9}{450 \times 4.7 \times 10^{-10}} = 8.5 \times 10^8$$

Of course the value of N necessary to produce a satisfactory radiograph depends on the plate used and upon the method and time of development.

The average value of the constant $K = \frac{kdt}{V}$ found in the experiments with the Sabouraud pastille was 2.5×10^{-8} .

As above

$$\begin{aligned} N &= \frac{kdt \ 3 \times 10^9}{Ve} \\ &= \frac{2.5 \times 10^{-8} \times 3 \times 10^9}{4.7 \times 10^{-10}} = 1.6 \times 10^{11}. \end{aligned}$$

This, then, gives the number of ions per c.c. formed in the air immediately surrounding the pastille during a change in tint corresponding to one number on Hampson's radiometer. Now the normal or epilation dose is determined by tint B, as it is called, and corresponds to a change equivalent to four numbers. Therefore, the number of ions per c.c.

produced in air surrounding the pastille during normal dose is $4N$ or about 6.4×10^{11} . In measuring this dose the pastille is ordinarily placed half way between the anticathode and the skin. Therefore the number of ions per c.c. produced near the surface of the skin during an epilation dose would be 1.6×10^{11} . This value is apparently very much smaller than that obtained by Dr. Szilard (*loc. cit.*), although there is some confusion in the part of his paper dealing with this calculation. A small part of this difference is due to the small value, 3.4×10^{-10} which he used for e , but the chief difference is due to the nature of the testing vessels used in the two experiments.

The vessel used by Dr. Szilard had a volume of 1 c.c. and was lined with lead. In a vessel of this kind the ionization due to secondary rays would be very large. Some of the secondary rays are very easily absorbed, but produce an intense ionization for a millimeter or two in air, so that their relative effect is especially great in a small vessel. The effect is also much greater with a lead than an aluminum vessel. Even in the large vessel used in the present investigation, the ionization was doubled by covering the plate C with lead foil. In the smaller vessel the ionization caused by the secondary rays might be several times as large as that due to the X-rays themselves. That the effect of the secondary rays from the aluminum plate C was small, was shown by covering C with a sheet of wet tissue paper, which reduced the ionization current less than 10%.

There is a still greater objection to using lead instead of aluminum for the interior of the testing vessel; namely the fact that the relative amount of secondary ionization depends on the hardness of the rays. The extra ionization in the testing vessel also requires the use of a higher voltage in order to prevent recombination.

SUMMARY.

1. It has been shown that the action of Roentgen rays on a photographic plate and on a Sabouraud pastille is

proportional to the ionization produced in the air immediately surrounding them.

2. A simple apparatus, making use of this principle, has been devised for measuring the intensity and hardness of the rays.

3. It has also been shown that this same apparatus can be easily used to determine the length of time of exposure needed to produce radiographs of suitable density.

In conclusion, I desire to express my indebtedness to Dr. Edward Weston for his kindness in fitting up and loaning me a galvanometer suitable for this work; to Principal Sexton and Professor Ayars of the Nova Scotia Technical College for the use of their X-ray apparatus, and especially to Dr. W. H. Eagar for his many helpful suggestions and for the use of his office and equipment.

Dalhousie University, Halifax, N. S.

March 15, 1915.

AN INVESTIGATION OF THE "CHROMATE METHOD" FOR
SEPARATING THE ALKALINE EARTHS.*—BY HUBERT
BRADFORD VICKERY, Dalhousie University, Halifax.

(Read 11 January 1915)

This investigation was undertaken with the twofold object of discovering the degree of sensitiveness of which the ordinary "chromate method" for the separation of the alkaline earths is capable, and also under what conditions this sensitiveness may be increased. Incidentally a considerable improvement was made in the procedure.

Throughout the experimental work the idea was kept constantly in mind to have the conditions of working as nearly as possible those which obtain in the manipulation of the average student of qualitative analysis, and where these have been changed, to make them very easily attainable, so that the final quantitative results might fairly represent the degree of accuracy obtainable in ordinary work.

While several methods exist for the separation of the alkaline earths which are extremely delicate, † they depend largely upon the use of alcohol and ether to decrease the solubility of the various precipitates, and hence are scarcely suitable for class use. The chromate method, on the contrary, uses water solutions alone and obviates the necessity for inconveniently long waits for complete precipitations, thus greatly decreasing the time required for a single analysis and making this method eminently suitable for use in class. The procedure ordinarily followed ‡ consisted in precipitating the carbonate in strongly alkaline solution, magnesium being held in solution by means of ammonium chloride. The

* Contributions from the Science Laboratories of Dalhousie University (Chemistry).

† J. Am. Chem. Soc., **30**, 611. (1903).

‡ G. S. Newth: Manual of Chemical Analysis, p. 35.

carbonates were then dissolved in the least possible quantity of acetic acid, the solution diluted, barium removed as chromate, and ammonium sulphate added to the filtrate. This was supposed to throw down the insoluble strontium sulphate, but retain the calcium by its solvent action upon calcium sulphate.

It was at this point that difficulty was usually encountered as the calcium almost invariably came down in some quantity, especially if present in large amounts, rendering a complete separation impossible and obscuring the confirmatory flame tests. However, sufficient calcium was retained to give the confirmatory oxalate test, and by again bringing the precipitate into solution and treating with a solution of calcium sulphate, the strontium was confirmed even in the presence of a large amount of calcium. This method, resulting as it does in only an approximate separation, is unsatisfactory, and attempts were made to improve it.

Solutions of barium, strontium and calcium as chlorides were made up and carefully standardized gravimetrically, the first two by precipitating a known volume with silver nitrate, and the last with ammonium oxalate. Appropriate volumes of these solutions were run from burettes into flasks and made up so that each solution should contain a milligram of the metal per cubic centimeter. These standard solutions were used for the analysis.

The first step was to investigate quantitatively each precipitation occurring throughout the procedure and record its delicacy under the conditions normally occurring in the course of an analysis. The method followed was to run various quantities of the standard solutions into a series of beakers, dilute them with hot water, and add the cold reagents in the order given. This resulted in the precipitation taking place at a temperature of 65°-70°. By watching the row of beakers it was easy to compare the amounts of precipitate occurring and to find that one which yielded no precipitate,

thus fixing a lower limit to the sensitiveness of the particular precipitation, and ensuring uniform conditions.

The reagents used were:—Ammonia sp. gr. .90 (equivalent to three times the volume of sp. gr. .96).

Ammonium Chloride.....	10%
Ammonium Carbonate.....	25%
Potassium Chromate.....	5%
Ammonium Sulphate.....	10%
Ammonium Oxalate.....	5%
Acetic Acid.....	50%

BARIUM CARBONATE

The precipitating reagents were 3cc NH_4OH , 10cc NH_4Cl , 10cc $(\text{NH}_4)_2\text{CO}_3$. The total volume of the solution was 100cc.

- 0.5 mg. of barium gave no precipitate.
- 1.0 mg. gave no precipitate.
- 2.0 mg. gave no precipitate.
- 3.00 mg. gave very slight deposit on lines of rubbing with glass rod.
- 5.0 mg. gave slight deposit.
- 7.0 mg. gave very slight precipitate.
- 10.0 mg. gave feathery crystalline precipitate in few moments.
- 25.0 mg. gave feathery precipitate almost at once.

STRONTIUM CARBONATE

Conditions same as above.

- 0.5 mg. of strontium gave no precipitate.
- 1.0 mg. gave very slight precipitate in 5 minutes.
- 2.0 mg. gave slight precipitate in four minutes.
- 4.0 mg. gave decided precipitate in few moments.
- 10.0 mg. gave fairly heavy precipitate, but not coming down instantly.
- 25.0 mg. gave heavy precipitate at once.

CALCIUM CARBONATE

Conditions same as above.

0.3 mg. of calcium gave no precipitate.

0.5 mg. gave no precipitate.

0.6 mg. gave very slight precipitate.

0.8 mg. gave slight precipitate.

1.0 mg. gave slight precipitate in 4 minutes.

5.0 mg. gave precipitate almost at once.

10.0 mg. gave heavy crystalline precipitate at once.

It was found that a temperature much in excess of 70° caused an interaction of the carbonate with the ammonium chloride, giving an evolution of carbon dioxide and resulting in the solution of the precipitate or complete failure to form a precipitate.

In each case completeness of precipitation of a solution containing 25 mg. of the metal was tested by filtering after ten minutes and allowing to stand over night. Only in the case of barium did any deposit form and even in this case it was in very small quantity. The precipitates were examined microscopically, but it was found that although the crystals when falling from very dilute solutions were quite easily differentiated, from more concentrated solutions they were almost indistinguishable, especially since calcium, and to a lesser extent barium, show a tendency to come down as gelatinous masses from cool solutions.

BARIUM CHROMATE.

Precipitating reagent, 3cc K_2CrO_4 . Total volume of solution, 100cc.

In neutral solution, even one tenth of a milligram of barium gave a cloudiness in five minutes, but in a solution containing 1-2cc acetic acid 2 mg. failed to give a precipitate, while 2.5 mg. gave a slight one on standing a few

minutes. 5 mg. gave a precipitate almost at once. Boiling temperature was used.

STRONTIUM CHROMATE

Precipitating reagent, 15cc K_2CrO_4 . Total volume of solution, 200cc.

In neutral solution 200 mg. of strontium gave a very slight deposit in beaker in ten minutes. 400 mg. gave a heavy precipitate in a few moments. In solution containing acetic acid, 500 mg. failed to give a precipitate over night.

CALCIUM CHROMATE

Conditions same as in precipitation of strontium chromate.

In neutral solution 500 mg. of calcium gave a barely perceptible precipitate in fifteen minutes, while in acid solution none formed at all.

The barium chromate when suddenly thrown down is very fine and scarcely crystalline, but boiling for a few minutes causes it to crystallize. Under the conditions of ordinary work there is little risk of obtaining a precipitate of strontium chromate, while the barium is almost completely removed.

STRONTIUM SULPHATE

Precipitating reagent, 10cc $(NH_4)_2SO_4$.

2 mg. failed to give a precipitate on boiling while 2.5 mg. gave a scarcely perceptible one. 4 mg. gave very slight precipitate on standing. 10mg. gave a precipitate in a few moments. The experiments were repeated with both neutral and acetic acid solutions, with practically identical results.

CALCIUM SULPHATE

Precipitating reagents, 2cc acetic acid, 10cc $(NH_4)_2SO_4$. Temperature, 70°C.

200 mg. gave heavy feathery precipitate at once.

100 mg. gave small precipitate in one minute, which rapidly increased in size.

90 mg. gave small precipitate on standing an hour.

75 mg. gave no precipitate on standing.

Thus, under the conditions of ordinary work, calcium when present in excess of 90 mg. is precipitated along with the strontium. 200 mg. of calcium, and 40cc of $(\text{NH}_4)_2\text{SO}_4$ gave a heavy precipitate on warming, but no solvent action was noticeable on boiling; 40cc more were added and boiled and a slight solvent action took place. On adding 40cc of ammonium chloride to this solution it was observed that the greater part of the precipitate went into solution on boiling for a few moments. As this action appeared important, it was determined to investigate it further.

To try the effect of the addition of ammonium chloride before precipitating the sulphate, two solutions of 400 mg. of calcium each were prepared. To No. 1 were added 40cc NH_4Cl and to each 1cc of acetic acid. Both were brought to 70° and 10cc $(\text{NH}_4)_2\text{SO}_4$ added. The effect of the ammonium chloride was very noticeable, for in five minutes only a very few crystals had appeared in No. 1, and very little deposit had formed on the bottom of the beaker, while in the second beaker the precipitation had been heavy and was nearly complete. Other experiments were tried, and it was found that 80cc of ammonium chloride solution were sufficient to prevent completely the precipitation of 200 mg. of calcium, while 50cc failed to do so, as a slight deposit formed on boiling. 160cc were sufficient to hold up 400 mg. of calcium, showing that there should be 80cc of ammonium chloride present for each 200 mg. of calcium. It was found that the total volume should be not less than 150cc as a smaller volume rendered the precipitation of the calcium more likely. The effect of the ammonium chloride upon the strontium was investigated, and it was found that in the presence of a large excess, 4 mg. gave a precipitate on boiling, while 3mg. gave a very slight turbidity. Thus the effect is scarcely appreciable. The amount

of ammonium chloride is perhaps somewhat excessive, but it was found that when much smaller quantities were used, the calcium was liable to fall when the solution was boiled or digested on the water-bath. It is quite easy to tell from the character of the precipitate at this point if the calcium is precipitating. The strontium precipitate is very fine grained and falls immediately. The calcium sulphate precipitate, especially if ammonium chloride is present, is feathery, crystalline and forms slowly. It usually forms first at the surface, and is particularly liable to come down on boiling.

CALCIUM OXALATE

0.1 mg. of calcium gave a perceptible precipitate on standing for a few minutes. The effect of ammonium chloride in considerable quantities seemed to be to make the precipitation rather slower, but 0.1 mg. could still be easily detected.

SENSITIVENESS OF METHOD

The next step in the investigation was to carry out a series of analyses under normal conditions, using large excess of two of the metals and varying small quantities of the third until it could no longer be detected by the methods used. In this way the limit of detectability for each metal in the presence of excess of the others was found *when the complete analysis is carried through*.

A solution containing 4 mg. of barium and 200 mg. each of calcium and strontium was made up. The carbonates were precipitated and allowed to digest at 70° for 15 minutes, and then filtered and dissolved as usual. A slight precipitate formed in 5 minutes after adding 5cc of the chromate and on boiling and filtering a distinct yellow deposit was left on the filter after washing the potassium chromate out. A similar solution, but containing only 3 mg. of barium

as chloride, failed to form a precipitate in 15 minutes, or to leave a deposit on the filter. Hence the limit of detection of barium using the ordinary procedure is 4 mg. when excess of the others is present.

A solution containing 15 mg. of strontium and 200 mg. each of calcium and barium was treated by the ordinary procedure and the barium removed. Insufficient ammonium chloride was added and a considerable precipitate formed with the ammonium sulphate. This was boiled with ammonium carbonate and dissolved in acetic acid and calcium sulphate added. A very fine precipitate formed in the course of a few hours. A similar solution was taken and sufficient ammonium chloride (i.e. 80cc) was added, after removing the barium, to hold up the calcium. A very fine granular precipitate was obtained with ammonium sulphate in a few minutes, and no trace of the typical calcium crystals. Its identity was easily established. A solution with 13 mg. of strontium failed to give a precipitate, hence the limit of detectability of strontium is 15 mg. when an excess of barium and calcium is present.

A solution containing 1 mg. of calcium, 200 mg. of barium and 500 mg. of strontium was treated as before, and the barium and strontium removed as chromate and sulphate respectively. A fine white precipitate appeared in a few moments on making alkaline and adding ammonium oxalate. A solution containing 0.5 mg. gave no precipitate on boiling 15 minutes, but gave a very fine deposit on standing over night. Hence, the limit of detectability of calcium is 1 mg. or somewhat under, when excess of barium and strontium are present.

PROPOSED PROCEDURE

The results of the investigation can best be summarized by giving a procedure with notes for the separation of the alkaline earths by the improved chromate process.

PROCEDURE I. *Precipitation of group (after ridding of sulphur).*

To solution after removal of iron and zinc group, (60cc), add 10cc NH_4OH , 20cc NH_4Cl and 20cc $(\text{NH}_4)_2\text{CO}_3$ at a temperature of 70° , and let stand several minutes. Filter and wash with little cold water.

Notes—1. At temperature much above 70° the carbonates react with the ammonium chloride forming the soluble chloride with evolution of carbon dioxide.

2. At temperature much lower calcium comes down as a gelatinous mass and barium also has this tendency. Warming on the water bath will cause them to crystallize.

3. Precipitation of strontium and calcium is complete in 10 minutes and of barium very nearly so.

PROCEDURE II. *Precipitation of Barium.*

Pour a 5cc portion of acetic acid through the filter a few drops at a time, and pour through repeatedly until it runs through clear. Then wash thoroughly with hot water. Make up to 80cc and heat to boiling. Add 5cc of K_2CrO_4 solution a few drops at a time with constant stirring and boil a few moments. Filter and wash with cold water. (Yellow precipitate shows presence of barium)

Notes—1. The 5cc of 50% acid should be diluted somewhat and used hot.

2. 500 mg. of calcium and strontium fail to precipitate under these conditions while 4 mg. of barium give a distinct test.

3. The filtrate should be yellow rather than red, but should be tested with another drop of chromate.

PROCEDURE III. *Confirmatory test for Barium.*

Pour a little hot HCl through the filter repeatedly and evaporate almost to dryness. Test in flame on platinum wire. Green color confirms barium.

PROCEDURE IV. *Precipitation of Strontium*

Evaporate to about 80cc and add 80cc of NH_4Cl for every 200 mg. of barium present; in no case less than 80cc. Add 10-15cc $(\text{NH}_4)_2\text{SO}_4$ solution. *Fine granular white precipitate* indicates strontium. Heat to boiling and let digest a few moments. Filter and wash with hot water.

Notes—1. Calcium, if present to the extent of 100 mg., will precipitate at this point unless held in solution by a large quantity of NH_4Cl . If a feathery precipitate in quite large crystals appears on heating, it is probably calcium.

2. Ammonium chloride inhibits the precipitate of strontium to only a very slight extent.

3. 15 mg. of strontium can be easily detected in the presence of large amounts of barium.

3. The confirmatory test should always be tried.

PROCEDURE V. *Confirmatory test for Strontium.*

Boil the precipitated sulphate with ammonium carbonate and neutralize with acetic acid. Concentrate to 10-20cc and filter if necessary. Add saturated solution of CaSO_4 and boil. Fine white precipitate confirms strontium.

Note—1. The strontium sulphate is converted to carbonate by the ammonium carbonate and brought into solution by the acid. The calcium is likewise converted but calcium acetate cannot give a precipitate with calcium sulphate, while the less soluble strontium sulphate separates at once on heating.

PROCEDURE VI. *Precipitation of Calcium.*

To the hot filtrate add NH_4OH to strongly alkaline reaction and then 10cc more. Add 20cc hot $(\text{NH}_4)_2\text{C}_2\text{O}_4$ solution and stir. White precipitate indicates barium.

Note—1. 1 mg. of calcium can be easily detected in the presence of 400 mg. of barium and strontium.

SUMMARY

1. Each precipitation occurring in the chromate process for the separation of the alkaline earths has been quantitatively investigated.

2. The chromate process has been found not to effect an exact separation of the three metals.

3. An improvement has been suggested by which the separation is practically complete, and a procedure formulated.

4. The limit of detectability for each metal by this procedure has been determined.

NOTES ON AN ABNORMAL WAVE OCCURRENCE ON THE NORTHERN CAPE BRETON COAST.—BY D. S. McINTOSH, B. A., M. Sc., Professor of Geology, Dalhousie University, Halifax, N. S.

(Read 12 April 1915)

The occurrence which formed the basis of this paper, while relatively of little importance, is thought by the writer to be of sufficient interest to be recorded in the Transactions of the Institute.

In a small indentation on the northern coast line of Cape Breton Island between Cape St. Lawrence and Bay St. Lawrence, is situated the little settlement of Meat Cove. It has no harbor, and the boats of the fishermen, after each trip, are hauled up on the beach beyond reach of the waves.

From correspondence with Mr. Joseph O'Brien, of Dingwall, Aspy Bay, supplemented by personal observation, Mr. A. H. McIntosh, of Pleasant Bay, furnished the writer with the following description of the wave phenomenon:

The monthly bulletin issued by the Department of Marine and Fisheries, Ottawa, gives the total catch of fish for Canada, also the kinds of fish, quantities and values. It also aims at giving such information as weather conditions during the month, loss of life, boats and gear among the fishermen.

In the copy for June 1914, we find this entry: "Nine boats were lost at Meat Cove, Victoria County." Had the facts connected with this loss been given they would have interested the readers of the publication. The following statement is given as what occurred. "On the evening of the night on which the boats were lost, the fishermen had

hauled them up on the beach to a place where they were considered to be in safety. A light wind began to draw from the land, and all the usual signs in which fishermen believe promised a fine night. Judge of the surprise of those men when on coming to the beach in the very early morning not only were their boats gone, but they were not even in sight on the sea. Eventually, one or two were found along the shore, but others were found only after some days had elapsed, picked up at great distances from the starting-place. The marks on the beach showed plainly that the tide had come up very much higher than usual, and while at this place, it seemed to have been the highest, it was also noted as an unusually high tide at Pleasant Bay on the west, and Bay St. Lawrence and Aspy Bay to the eastward. One man near Bay St. Lawrence, at about eleven o'clock, saw it come in the form of two large seas succeeding each other, and rushing on shore. A fishing schooner lying some two miles off shore also reports several heavy seas striking the vessel about the hour mentioned; otherwise the night was calm. Some six years before, this same vicinity was visited by something of the same nature, but as it came in the day, it occasioned no loss."

The above account shows plainly that the disturbance was abnormal. That it falls outside the category of tide phenomena is evident. It occurred on a calm night and consisted of a succession of high waves which continued for a brief period of time. Tidal waves of the nature of a bore or as the result of conflicting currents are in the highest degree improbable as an explanation. In searching about for a probable cause, one recalls some well-known and strikingly disastrous effects of great abnormal sea-waves.

In 1755, Lisbon was laid in ruins by an earthquake which had its origin about 50 miles off the coast. About half an hour after the shock, a succession of high waves, one of which had a height of 60 feet, reached the city and added

to the destruction wrought by the earthquake. The waves were felt with diminishing effects at great distances, even north as far as Norway, south beyond the Madeira Islands, and west in the West Indies.

Japan was visited by a severe earthquake in 1854. Its focus was also evidently off the coast, for about a half hour after the shock, a series of waves thirty feet high struck the shore and destroyed the town of Simoda. From this spot the waves radiated with diminishing force, travelling the whole breadth of the Pacific to California.

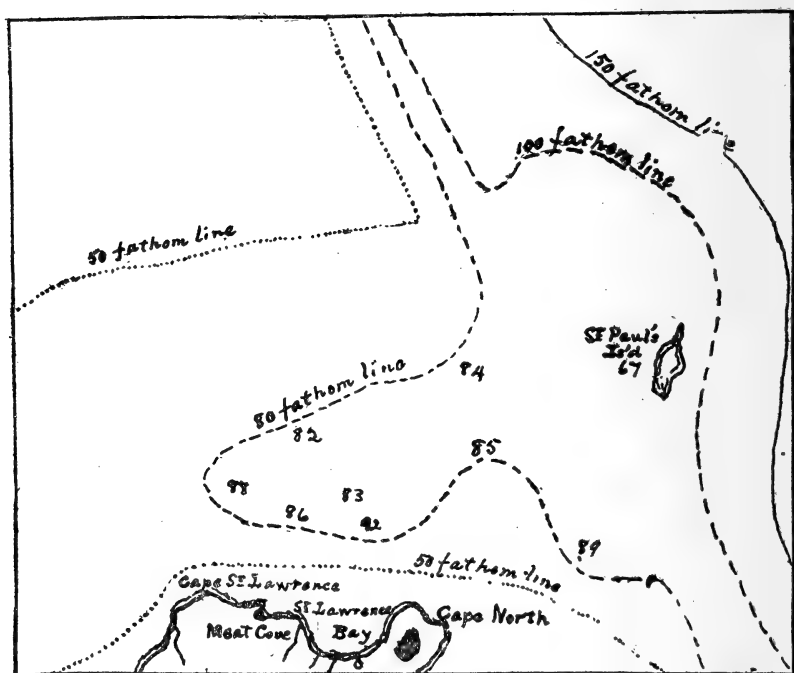
The Coast of Peru was devastated by a great earthquake in 1868. The seat of disturbance was likewise off shore, for in less than half an hour a succession of waves fifty or sixty feet high rushed in and increased the work of destruction of the earth-waves. These waves were felt thousands of miles from the seat of origin, even as far as the coast of Japan, 10,000 miles away.

Many other cases of such waves have been observed and recorded by tidal gauges, such as that of 1877 at Iquique in Northern Chile, and that of 1885 around Krakatoa. The great disturbance of 1896 in the North Pacific will be recalled by many, where 175 miles of the Japan Coast were laid waste. A great amount of shipping was destroyed and 27,000 people lost their lives.

These waves are caused by a dislocation of the earth's crust beneath the sea. The break occurs most often where the water deepens rapidly, as in the case of the western coast of South America where a few miles off shore the water suddenly plunges from the edge of the continental shelf to the ocean abyss. Similarly, off the Japan Islands the descent from the land platform to the Tuscorora Deep is very abrupt. The evidence is abundant and strong that such a condition of land and sea makes a line of weakness in the earth's crust and here may, and does, occur faulting or slipping. As

observed from the shore, the sea, during a disturbance of this kind withdraws from the land, and then returns with great speed and height causing great destruction.

In the opinion of the writer, the cause of the disturbance in Northern Cape Breton was a slipping of the rock, either solid or unconsolidated material, off the coast of Meat Cove. The accompanying map shows the locality where the disturbance was greatest, and the adjoining areas.



It is seen that a short distance east of St. Paul's Island the water deepens very rapidly. Here is the western margin of the submerged channel of the old St. Lawrence river. The 100-fathom line approaches to within about a mile of the island. Here, where there is a declivity of steep grade, a slipping or break in the bottom might be looked for. No

record of the disturbance, however, is obtained from St. Paul's Island, and, moreover, the description of the phenomenon localizes it rather between the island and the adjoining Cape Breton coast. The *isobathic* lines constructed from the chart show the 50-fathom line about two miles off Meat Cove, with the 80-fathom line about an equal distance beyond that. Here, in all probability, was the seat of the disturbance. A deepening of 80 fathoms in about 4 miles gives a gradient of about 1 foot in 44 feet or a $2\frac{1}{4}\%$ grade. The depths as given on the chart within the area bounded by the 80-fathom line suggest an uneven bottom where may be found steep slopes. Doubtless a large thickness of unconsolidated material has accumulated on the sea bottom. A sliding of this along the slope or a break in the solid rock would give the necessary impetus to the water to produce the waves.

When weather indications point to a calm night, boats are hauled up by the fishermen just beyond the range of high tides. The average difference between high and low water at Meat Cove, we may take as about four feet. To sweep the boats away would require an additional height of water of, say, three or four feet. Waves, therefore, of six or eight feet must have rolled in upon the shore to accomplish the work recorded. If the ordinary proportion between height and length of wave were preserved, the length of these waves must have been sixty or eighty feet. A slip of a belt of rock a hundred or so feet in width on the sea bottom near the 80-fathom line, or within the area bounded by this line would cause a gravitational movement to the water from the landward direction, followed by a return of the water, in the form of a succession of high waves. These waves would diminish in force as they radiated from the place of origin, as was observed to the eastward and westward of Meat Cove. Did the dislocation produce a rise in the sea

flow, the water would be lifted and the accompanying phenomena would be of the same nature as those that would occur in the case of the downward movement.

From the occurrence of a similar wave disturbance at Bay St. Lawrence some years before, as reported, it would be inferred that the surface of the sea bottom is unstable off the coast of Northern Cape Breton, and that such disturbances may recur until the area has arrived at a state of stability.

ACCIDENTAL ELECTRICAL STIMULATION OF THE HUMAN
RETINA IN SITU. — BY D. FRASER HARRIS, M. D.,
D. Sc., F. R. S. E., Professor of Physiology in Dal-
housie University, Halifax.

(Read 10 May 1915)

In the summer of 1912 I had a lower left molar tooth filled with a temporary stopping consisting of an amalgam of at least three metals, silver, mercury, and tin. Within half an hour of having this inserted I noticed that each time I clenched the jaws at all forcibly, there appeared a bright flash of light in the left eye; all through the rest of the day flashes of light, getting fainter and fainter, kept recurring. I noticed that the tooth in the upper jaw which touched the amalgam in the lower was gold-capped. The light experienced was of a canary yellow and more like the sensation of a vivid lightning flash (forked lightning) than of any mere luminosity or diffusion of light. So vivid were these subjective flashes that my first thought was that there had been lightning, but on the day in question there was no lightning, thunder or rain.

The first explanation that occurred to me was that this was a case of "contact electricity" (Kelvin), that the dissimilar metals—the gold of the upper tooth and the amalgam of the lower—having been in contact in the liquid saliva, produced sufficient current to stimulate the retina heterologously. But the following experiment seemed to be against this; I held between the teeth a copper rod in contact with a silver rod, but no flash of light was experienced when these metals were pressed together.

The next explanation which occurred to me was that the crystallization of the amalgam could give rise to currents sufficiently intense to be the cause of physiological stimulation. Dr. Frank Woodbury kindly told me that he had

known of currents caused in this way being sufficiently intense to give pain in the upper gold-covered tooth when that tooth had an unduly sensitive nerve. I therefore suggest that the electric current thus produced was conducted through the bones and tissues of the head and, encountering the retina en route, stimulated it to give rise to the subjective sensations of light. The possibility of stimulating the retina in situ by electric current was discovered by Ritter in 1800; a constant current passed either transversely across the head in the temporal regions or from the eyelid to the neck will, both at make and break, stimulate the retina causing flashes of light to be perceived. I renewed my acquaintance with these effects by passing the constant current from one dry cell through the eyes transversely across the head; at the make and break the flashes due to this current were slightly less vivid than the flashes due to the tooth-current. On using two dry cells, I obtained flashes closely resembling those from the tooth-current. I am assured that the current from two dry cells would be painful to the inflamed nerve of a tooth.

It is well known that pressure on the eye-ball produces the sensation of light—the phosphene. I noticed that the subjective flashes from two dry cells were not quite so vivid as the phosphene from moderate (non-painful) pressure on the eye-ball. The electrically produced flashes are more diffuse than the phosphene which has a circular outline; the sensations from dry cells or the tooth-current are more truly flashes.

Based on these considerations, I make an attempt to estimate the amount of the tooth-current, say, during the first few seconds of its production. Assuming that the resistance of the head is about 3000 ohms, and that each dry cell can develop 1.5 volts; then, for two cells, we have

$$C = \frac{1.5 \times 2}{3000} = \frac{1}{1000} \text{ of an ampere or one milliampere.}$$

ADDITIONS TO THE CATALOGUE OF BUTTERFLIES AND MOTHS
COLLECTED IN THE NEIGHBOURHOOD OF HALIFAX,
ETC., NOVA SCOTIA.—BY JOSEPH PERRIN, McNab's
Island, Halifax.

(Read 12 April 1915)

In the Transactions of this Institute, volume xii, part 3 (for 1908-09), Halifax, 1912, pages 258-290, there was published a Catalogue of Butterflies and Moths mostly collected in the neighbourhood of Halifax and Digby, by the present writer and Mr. John Russell, then of the latter place. Since 1909 the writer has continued collecting these insects, and has also received specimens and records of captures from Mr. George E. Sanders, field officer of the Department of Agriculture, entomological laboratory, Bridgetown, Annapolis County, N. S., and from Mr. E. Chesley Allen of Yarmouth, N. S. To those two gentlemen I wish to express my thanks.

In the present supplementary paper there is presented a list of two Butterflies and sixty Moths which were not previously reported; with additional remarks on species before listed, and on such as have been taken at Halifax for the first time. These notes are arranged in two groups: (a) species not hitherto reported from Nova Scotia, and (b) additional notes on species previously reported.

Our previous catalogue contained 60 nominal species and varieties of Butterflies, and 480 of Moths; total 540. The present supplement brings the number up to 62 Butterflies and 540 Moths, total 602.

The nomenclature and arrangement is that of Dr. Harrison G. Dyar's *List of North American Lepidoptera* (Bulletin U. S. National Museum, No. 52; Washington, 1902), and his numbers are prefixed.

(49)

All the specimens from McNab's Island (which is situated in the mouth of Halifax Harbour) were taken by myself; other localities have attached the names of those responsible for the records for those places. As before, doubtful specimens have been referred, as far as possible, to specialists for their opinion.

Species not hitherto reported from Nova Scotia.

Order LEPIDOPTERA.

RHOPALOCERA (Butterflies).

Superfamily PAPILIONOIDEA.

Family PIERIDÆ.

65. *Eurymas eurytheme* Bois. MacNab's Is., Halifax; Sept. 4, 1910, female; Sept. 12, 1913, male. (Perrin).

Family LYCENIDÆ.

432. *Rusticus scudderi* Edw. South East Passage, Halifax County; July 3, 1911, one male; and August 9, 1914, one male and one female. (Perrin).

HETEROCERA (Moths).

Superfamily SPHINGOIDEA.

Family SPHINGIDÆ.

706. *Sphinx chersis* Hübner. Digby, N. S.; July 26, 1907. (Russell).
721. *Ceratomia amyntor* Geyer. Bridgetown; June 16, 1913. (Sanders).

Superfamily BOMBYCOIDEA.

Family LITHOSIIDÆ.

808. *Hypoprepia fucosa* Hübner. Yarmouth; July 27, 1913. (Allen).

Family ARCTIIDÆ.

828. *Eubaphe læta* Guérin. Deerfield, Yarmouth Co.; July 28, 1913. (Allen).
853. *Estigmene prima* Slosson. South East Passage, Halifax Co.; June 9, 1912. (Perrin).

Family NOCTUIDÆ.

Subfamily Noctuinae.

- 960. *Panthea acronyctoides* Walker. MacNab's Is.; June 15, 1912.
- 1158. *Hadena modica* Guenée. MacNab's Is.; August 20, 1909, at light.
- 1418. *Platagrotis pressa* Grote. MacNab's Is.; July 15, 1912, at light.
- 1455. *Agrotis geniculata* Grote & Robinson. Deerfield, Yarmouth Co., August 16, 1911. (Allen).
- 1788. *Mamestra liquida* Grote. MacNab's Is.; July 14, 1911, at light.
- 2060. *Tricholita signata* Walker. MacNab's Is.; August 6, 1911.
- 2078. *Xylina disposita* Morrison. MacNab's Is.; Sept. 26, 1913, at light.
- 2079. *X. petulca* Grote. MacNab's Is.; Oct. 21, 1912.
- 2090. *X. antennata* Walker. Bridgetown; Sept. 17, 1913. (Sanders).
- 2092. *X. grotei* Riley. (*X. cinerosa* Grote.) Bridgetown; Oct. 11, 1913. (Sanders).
- 2095. *X. innominata* Smith. Bridgetown. (Sanders).
- 2102. *X. georgii* Grote. Bridgetown; Sept. 24, 1913. (Sanders).
- 2106. *X. unimoda* Lintner. Bridgetown; Oct. 17, 1913. (Sanders).
- . *Hydroecia micacea* Esp. Bridgetown; Oct. 10, 1912. (Sanders).
- 2244. *Scopelosoma devia* Grote. Yarmouth; May 17, 1913. (Allen).

52 ADDITIONS TO CATALOGUE OF BUTTERFLIES AND MOTHS

Subfamily Catocalinæ.

2905. *Catocala gracilis* Edw. MacNab's Is.; Aug. 21, 1914.
3006. *Erebus odora* Linn. Yarmouth; about June 20, 1906.
(Allen).

Subfamily HYPENINÆ.

3039. *Chytolita morbidatis* Guenée. MacNab's Is.; July 8, 1912, at light.

Family NYCTEOLIDÆ.

3083. *Nycteola revayana* Scopoli. MacNab's Is.; Sept. 19, 1914.

Family LASIOCAMPIDÆ.

- 3221c. *Malacosoma disstria erosa* Stretch. MacNab's Is.; July 8, 1911, at light (Perrin); common at Bridge-town (Sanders).

Family GEOMETRIDÆ.

Subfamily Hydriomeninæ.

3352. *Eustroma triangulata*. Deerfield, Yarmouth Co.; July 28, 1913 (Allen)

Subfamily Sterrhinæ.

3551. *Eois anticaria* Walker. MacNab's Is.; July 7, 1910.

Subfamily Geometrinæ.

3578. *Synchlora ærata* Fab. MacNab's Is.; July 9, 1912, at light.

Subfamily Ennominae.

3881. *Phigalia titea* Cramer. MacNab's Is.; April 27, 1914.
3898. *Anagoga pulveraria* Linn. MacNab's Is.; July 14, 1907.
3931. *Plagodis phlogosaria* Guenée. MacNab's Is.; July 14, 1914. There is some uncertainty as to the determination of this specimen. It was at first named *Plagodis altruaria* by Dr. Henry Skinner of the Academy of Natural Sciences, Philadelphia, after inspection of the specimen itself. This name does not appear in Dyar's List and possibly is a

new one. Subsequently it was determined as *Plagodis phlogosaria*, Guenée, by Mr. Albert F. Winn of Westmount, Montreal, from a drawing of the specimen.

3947. *Gonodontis obfirmaria* Hübner. South East Passage, Hx. Co.; June 8, 1912. (Perrin).
 3956. *Euchlæna obtusaria* Hübner. Deerfield, Yar. Co.; July 8, 1913. (Allen).
 3960. *E. johnsonaria* Fitch. Deerfield, Yar. Co.; July 6, 1913. (Allen).
 4028a. *Abbotana clemataria transducens* Walker. Dartmouth, Hx. Co.; June, 1907. (Perrin).

Family EPIPLEMIDÆ.

4043. *Callizzia amorata* Packard. Digby; July 16, 1908. (John Bussell).

Superfamily TINEOIDEA.

Family PYRALIDÆ.

Subfamily Pyraustinae.

4410. *Phlyctænia terrealis* Treitschke. MacNab's Is.; July 16, 1912.
 4451. *Pyrausta rubricalis* Hübner. MacNab's Is.; June 10, 1910.

Subfamily Scopariinae.

4510. *Scoparia centuriella* Denis & Schifferrmüller. Digby; June 23, 1908 (Russell). MacNab's Is.; July 8, 1911 (Perrin).

Subfamily Pyralinae.

4511. *Aglossa cuprealis* Hübner. MacNab's Is.; June 20, 1911.

Subfamily Schœnobiinae.

4547. *Schœnobias forcicellus* Thunberg. MacNab's Is.; July 14, 1911.

Subfamily Crambinae.

4560. *Crambus hamellus* Thunberg. Yarmouth. (Allen).
 4566. *C. unistriatellus* Packard. Yarmouth, July 30, 1912.
 (Allen).
 4574. *C. alboclavellus* Zeller. Yarmouth. (Allen).
 4579. *C. hortuellus* Hübner. Yarmouth. (Allen).
 4580. *C. perlellus* Scopoli. Yarmouth; August 14, 1911.
 (Allen).
 4583. *C. myellus* Hübner. Yarmouth. (Allen).
 4585. *C. vulgivagellus* Clemens. MacNab's Is.; Aug. 10,
 1909.
 4587. *C. ruricolellus* Zeller. Yarmouth. (Allen).

Subfamily Phycitinae.

4874. *Ephestia kuehniella* Zeller. MacNab's Is.; Jan. 8,
 1915. This pest has only lately been imported
 into the Island in one of the cereals for family
 use (Perrin).

Family PTEROPHORIDÆ.

4981. *Pterophorus monodactylus* Linn. MacNab's Is. (Perrin).
 Yarmouth, Sept. 20, 1913 (Allen).

Family TORTRICIDÆ.

Subfamily Olethreutinae.

5031. *Olethreutes nimbatana* Clemens. Bridgetown; Aug.
 9, 1912. (Sanders).
 5142. *Eucosma otiosana* Clemens. Bridgetown; Aug. 8,
 1912. (Sanders).
 5143. *E. similana* Hübner. Bridgetown; Sept. 2, 1912.
 (Sanders).
 5237. *Tmetocera ocellana* Schiffermüller. Bridgetown; Aug.
 13, 1913. (Sanders).

Subfamily Tortricinæ.

5335. *Cenopsis reticulatana* Clemens. Bridgetown; Aug. 16, 1912. (Sanders).
5382. *Platynota flavedana* Clemens. MacNab's Is.; July 7, 1911.
5391. *Pandemis limitata* Robinson. Bridgetown; Aug. 15, 1912. (Sanders).
5406. *Tortrix fumiferana* Clemens. MacNab's Is.; July 7, 1911; at light.

Family ECOPHORIDÆ.

5894. *Simioscopsis allenella* Walsingham. MacNab's Is.; July. 19, 1911.

Additional notes on species previously reported.

Family NOCTUIDÆ.

975. *Apatela dactylina* Grote. MacNab's Is.; June 26, 1908.
1053. *Harrisimemna trisignata* Walk. One specimen, MacNab's Is.; July 9, 1912.
1067. *Chytonix palliatricula* Guenée. Reported by J. Russell as very common at Digby; but only one specimen has been taken at MacNab's Is., July 11, 1911, in sixteen years of collecting.

Family GEOMETRIDÆ.

3331. *Venusia comptaria* Walk. Only four specimens of this pretty little moth were taken by J. Russell at Digby, the last being captured on July 20, 1908. Four years later one specimen was collected at MacNab's Is.; July 18, 1912.
3370. *Percnoptilota fluviata* Hübn. Several forms were taken at light on MacNab's Is., in July, 1912.

3390. *Hydriomena tæniata* Stephens. The moth so named by us has been redetermined *Larentia* [*Hydriomena*] *basaliata* Walk., by Mr. A. F. Winn of Montreal from a specimen taken by me at MacNab's Is., August 14, 1914. Mr. Winn says that *H. tæniata* is European, and has not as yet been taken on this side. Dyer considered *H. basaliata* Walk., as a synonym of *H. tæniata* Stephens. It is merely a question as to the two forms being distinct.

3909. *Therina athasiaria* Walk. MacNab's Is.; May 26, 1910.

Family SESIIDÆ.

4191. *Bembecia marginata* Harris. This species has also been taken at Yarmouth by Mr. E. C. Allen, August 29, 1912.

THE PHENOLOGY OF NOVA SCOTIA, 1914—By A. H. MACKAY, LL.D.

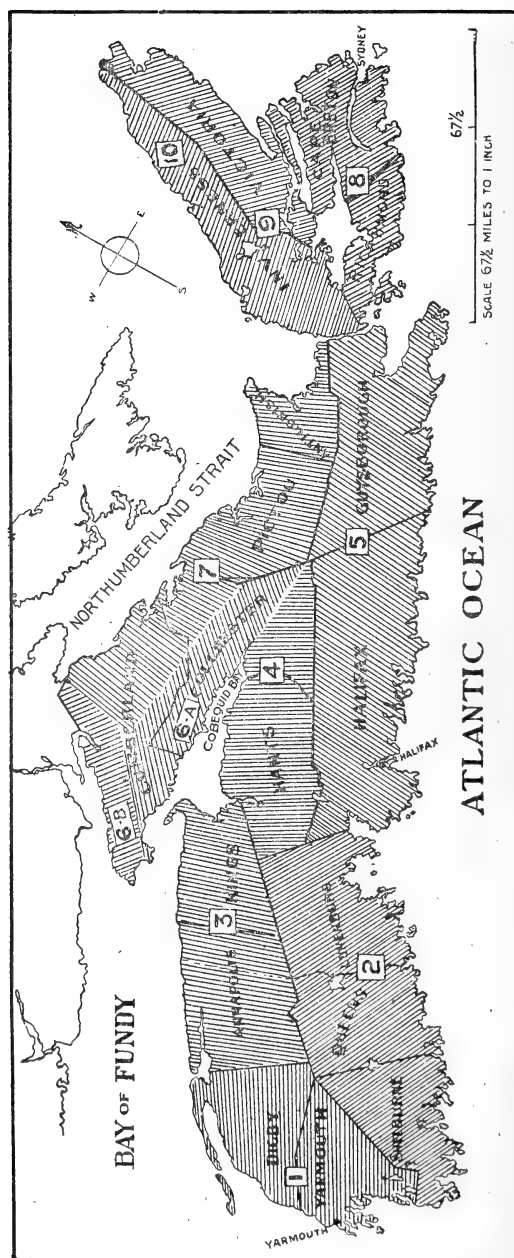
(Read by title 12 May 1915)

These phenological observations were made in the schools of the province of Nova Scotia as a part of the Nature Study work prescribed. The pupils report or bring in the flowering or other specimens to the teachers when they are first observed. The teachers record the first observation and observer, and vouch for the accurate naming of the species. The schedules from 350 of the best schools form the material of the following system of average dates (phenochrons) for the ten biological regions of the Province, and the phenochrons of the Province as a whole. The averaging of these schedules was done by H. R. Shinner, B. A. The * marks dates not averaged.

The Province is divided into its main climate slopes or regions not always coterminous with the boundaries of counties. Slopes, especially those to the coast, are subdivided into belts, such as (a) the coast belt, (b) the low inland belt, and (c) the high inland belt, as below:—

No.	Regions or Slopes.	Belts.
I.	Yarmouth and Digby Counties,	(a) Coast, (b) Low Inlands, (c) High Inlands.
II.	Shelburne, Queens & Lunenburg Co's.	" " "
III.	Annapolis and Kings Counties,	(a) Coast, (b) North Mt., (c) Annapolis Valley, (d) Corn- wallis Valley, (e) South Mt.
IV.	Hants and Colchester Counties,	(a) Coast, (b) Low Inlands, (c) High Inlands.
V.	Halifax and Guysboro Counties,	" " "
VI.A.	Cobequid Slope (to the south),	" " "
VI.B.	Chignecto Slope (to the northwest),	" " "
VII.	Northumberland Sts Slope (to the n'h)	" " "
VIII.	Richmond & Cape Breton Co's.,	" " "
IX.	Bras d'Or Slope (to the southeast),	" " "
X.	Inverness Slope (to Gulf, N. W.),	" " "

The ten *regions* are indicated on the outline map on the next page.



THE TEN PHENOLOGICAL REGIONS OF NOVA SCOTIA.

THE PHENOLOGY OF NOVA SCOTIA, 1914.

[Compiled from over 350 local observation schedules.]

WHEN FIRST SEEN.										WHEN BECOMING COMMON.										
OBSERVATION REGIONS.										OBSERVATION REGIONS.										
YEAR 1914.										YEAR 1914.										
Day of the year corresponding to the last day of each month.										Day of the year corresponding to the last day of each month.										
Jan. 31										July 212										
Feb. 59										Aug. 243										
March. 90										Sept. 273										
April. 120										Oct. 304										
May. 151										Nov. 334										
June. 181										Dec. 365										
For leap year add one to each except January.										For leap year add one to each except January.										
Average Dates										Average Dates										
1. Yarmouth and Digby	120	112	129	125	121	120	124	130	133	10. Inverness Slope to Gulf	125	120	112	129	125	121	120	124	130	133
2. Shelburne, Queens and Lunenburg	131	126	133	136	125	131	128	131	128	9. Bras d'Or Slope, Inverness and Victoria	131	126	133	136	125	131	128	131	128	133
3. Annapolis and Kings	124	116	126	123	124	120	124	130	133	8. Richmond and Cape Breton	124	116	126	123	124	120	124	130	133	133
4. Hants and South Colchester	141	138	137	136	139	148	143	142	144	7. N. Cumb. Col. Pictou and Antigonish	141	138	137	136	139	148	143	142	144	146
5. Halifax and Guysboro	140	139	130	136	141	143	144	142	144	6. S. Cobequid Slope, (S. Cumb. & Col.)	140	139	130	136	141	143	144	142	144	144
6. S. Cobequid Slope, (S. Cumb. & Col.)	140	134	127	136	142	139	138	142	146	5. Halifax and Guysboro	140	134	127	136	142	139	138	142	146	150
7. N. Cumb. Col. Pictou and Antigonish	143	135	133	138	144	141	142	144	151	4. Hants and South Colchester	143	135	133	138	144	141	142	144	151	151
8. Richmond and Cape Breton	146	129	141	137	136	139	136	139	147	3. Annapolis and Kings	146	129	141	137	136	139	136	139	147	147
9. Bras d'Or Slope, Inverness and Victoria	139	136	134	136	139	136	141	139	146	2. Shelburne, Queens and Lunenburg	139	136	134	136	139	136	141	139	146	146
10. Inverness Slope to Gulf	141	175	168	170	172	176	175	175	180	1. Yarmouth and Digby	141	175	168	170	172	176	175	175	180	148
1. Alnus incana, Wild.	143	139	134	139	142	143	145	152	148	2. Populus tremuloides	143	139	134	139	142	143	145	152	148	148
2. Populus tremuloides	151	150	152	149	144	154	152	150	150	3. Epigea repens, L.	151	150	152	149	144	154	152	150	150	150
3. Epigea repens, L.	146	142	140	146	145	146	144	146	145	4. Equisetum arvense	146	142	140	146	145	146	144	145	145	145
4. Equisetum arvense	144	140	138	142	141	143	144	142	144	5. Sanguinaria Canadensis	144	140	138	142	141	143	144	145	145	145
5. Sanguinaria Canadensis	143	139	130	136	141	143	144	142	144	6. Viola blanda	143	139	130	136	141	143	144	145	145	145
6. Viola blanda	143	135	133	138	144	141	142	144	147	7. Viola palmata, cucullata	143	135	133	138	144	141	142	144	147	151
7. Viola palmata, cucullata	146	129	141	137	136	139	136	139	147	8. Hepatica triloba, etc.	146	129	141	137	136	139	136	139	147	147
8. Hepatica triloba, etc.	139	136	134	136	139	136	141	139	146	9. Acer rubrum	139	136	134	136	139	136	141	139	146	146
9. Acer rubrum	141	175	168	170	172	176	175	175	180	10. Fragaria Virginiana	141	175	168	170	172	176	175	175	180	148
10. Fragaria Virginiana	143	139	134	139	142	143	145	152	148	fruit ripe	143	139	134	139	142	143	145	152	148	
fruit ripe	151	150	152	149	144	154	152	150	150	Taraxacum officinale	151	150	152	149	144	154	152	150	150	
Taraxacum officinale	146	142	140	146	145	146	144	146	145	Erythronium Americanum	146	142	140	146	145	146	144	145	145	
Erythronium Americanum	144	140	138	142	141	143	144	145	145	Coptis trifolia	144	140	138	142	141	143	144	145	145	
Coptis trifolia	151	150	152	149	144	154	152	150	150	Claytonia Caroliniana	151	150	152	149	144	154	152	150	150	
Claytonia Caroliniana	144	140	138	142	141	143	144	145	145	Nepeta Glehoma	144	140	138	142	141	143	144	145	145	
Nepeta Glehoma	151	150	152	149	144	154	152	150	150		151	150	152	149	144	154	152	150	150	

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, 1914.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION REGIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. and Col.)	7. North Cum., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.	Total Year 1914.
.....	10	.....	.....	.....	.....	.....	56	.....	.....	10
.....	59	.....	56
.....	62	.....	59
.....	63	.....	.....	62
.....	65 ²	.....	.....	63
.....	66 ¹³	66 ²	.....	65 ²
.....	68	.....	.....	.....	.....	70 ²	.....	66 ¹⁵
.....	71 ⁴	.....	.....	68
.....	74	.....	.....	.....	.....	.....	.....	.....	70 ²
.....	75	.....	.....	.....	.....	.....	.....	.....	.....	71 ⁴
.....	74
.....	75
.....	76	.....	.....	.....	.....	.....	.....	76
77 ³	77 ¹¹	77 ⁴	77 ⁷	77 ³	.....	.....	.....	77	.....	77 ²⁹
.....	78 ⁹	78 ²	.....	78 ¹²	.....	.....	.....	78 ²³
.....	83	.....	.....	.....	.....	.....	83
.....	95	.....	.....	95
.....	97	.....	.....	97
.....	102	.....	102	.....	.....	.....	102 ²
.....	105	.....	.....	105	.....	.....	.....	105 ²
.....	109 ²	109 ⁴	.....	109	109 ²	.....	.....	.....	109 ⁹
.....	110	.....	.....	.....	.....	110
113.	113
.....	118	.....	.....	.....	.....	.....	.....	.....	.....	118
.....	119	.....	.....	.....	.....	.....	.....	.....	119
.....	128	.....	.....	.....	.....	.....	.....	128
.....	129	129 ⁶	.....	.....	129 ¹³	129 ³	.....	129 ²²
.....	130	.....	.....	130	.....	.....	130 ²
.....	131	.....	.....	131 ³	131	.....	131 ⁵
.....	132	.....	.....	132
.....	133	.....	133	.....	.....	.....	.....	.....	133 ²
.....	134	.....	.....	.....	.....	.....	134
.....	135 ⁶	.....	.....	135 ¹⁰	.....	135	.....	135 ¹⁷
136	136	.....	136	.....	.....	136 ²	.....	.....	136 ⁵
.....	138	.....	.....	.....	.....	.....	138	.....	.....	138 ²
.....	141	.....	.....	.....	.....	.....	141 ⁹
144	144
.....	145	.....	.....	.....	.....	.....	145	.....	.....	145
.....	146	.....	.....	146 ²
.....	147	147	.....	147	147 ²	147 ³	147	.....	147 ⁹

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, 1914.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION REGIONS.

[illegible]

APPENDIX I

LIST OF MEMBERS, 1914-15

ORDINARY MEMBERS

	<i>Date of Admission</i>
Barnes, Albert Johnstone, B. sc., service inspector, Maritime Telephone & Telegraph Co., Halifax.....	May 13, 1912
Bishop, Watson L., Dartmouth, N. S.....	Jan. 6, 1890
Bowman, Maynard, B. A., Public Analyst, Halifax.....	Mar. 13, 1884
Bronson, Prof. Howard Logan, PH. D., Dalhousie College, Halifax.....	Mar. 9, 1911
Brown, Richard H., Halifax.....	Feb. 2, 1903
*Campbell, Donald A., M. D., Halifax.....	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax.....	Nov. 10, 1884
Colpitt, Parker R., City Electrician, Halifax.....	Feb. 2, 1903
Creighton, Prof. Henry Jeremian Maude, M. A., M. SC., DR. SC., F. C. S., Swarthmore College, Swarthmore, Penn., U. S. A.....	Jan. 7, 1908
*Davis, Charles Henry, C. E., New York City, U. S. A.....	Dec. 5, 1900
Doane, Francis William Whitney, City Engineer, Halifax.....	Nov. 3, 1886
Donkin, Hiram, M. E., Deputy Com. of Mines, Halifax.....	Nov. 30, 1892
Fergusson, Donald M., F. C. S., Chemist, Acadia Sugar Ref. Co., Dartmouth.....	Jan. 5, 1909
*Fraser, Sir C. Frederick, LL. D., Principal, School for the Blind, Halifax.....	Mar. 31, 1890
Freeman, Phillip A., Hx., Elect. Tramway Co., Halifax.....	Nov. 6, 1906
Graham, Prof. Stanley Newlands, B. SC., N. S. Technical College, Halifax.....	Nov. 28, 1913
Harlow, A. C., Montreal.....	Jan. 7, 1908
Harris, Prof. David Fraser, M. D., D. SC., F. R. S. E., Dalhousie College, Halifax.....	Feb. 29, 1912
Hatcher, Prof. Alfred G., Royal Naval College of Canada, Halifax.....	Dec. 9, 1914
Hattie, William Harrop, M. D., Dartmouth.....	Nov. 12, 1892
Irving, G. W. T., Education Dept., Halifax.....	Jan. 4, 1892
Johnstone, J. H. L., Demonstrator of Physics, Dalhousie University, Halifax.....	Dec. 2, 1912
*Laing, Rev. Robert, Halifax.....	Jan. 11, 1885
McCallum, A. L., B. SC., analyst, Halifax.....	Jan. 7, 1908
McCarthy, Prof. J. B., B. A., M. SC., King's College, Windsor, N. S.....	Dec. 4, 1901
McColl, Roderick, C. E., Halifax.....	Jan. 4, 1892
McInnes, Hector, K. C., Halifax.....	Nov. 27, 1889
MacIntosh, Prof. Donald Sutherland, B. A., M. SC., Dalhousie College, Halifax.....	Mar. 9, 1911
*McKay, Alexander, M. A., Supervisor of Schools, Halifax.....	Feb. 5, 1872
*MacKay, Alexander Howard, B. A., B. SC., LL. D., F. R. S. C., Superintendent of Education, Halifax.....	Oct. 11, 1885
Mackay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax.....	Nov. 27, 1889
*MacKay, George M. Johnstone, Schenectady, N. Y., U. S. A.....	Dec. 28, 1903
Mackenzie, Prof. Arthur Stanley, PH. D., F. R. S. C., Dalhousie College, Halifax.....	Nov. 7, 1905
Moore, Prof. Clarence L., M. A., F. R. S. C., Dalhousie College, Halifax.....	Jan. 7, 1908
Murphy, Martin, D. SC., I. S. O., Moncton, N. B.....	Jan. 15, 1870
Murray, Prof. Daniel Alexander, PH. D., Montreal.....	Dec. 18, 1903
Nickerson, Carleton Bell, M. A., Dalhousie College, Halifax.....	Mar. 9, 1911

*Life Members.

LIST OF MEMBERS

	<i>Date of Admission</i>
Piers, Harry, Curator Provincial Museum and Librarian Provincial Science Library, Halifax.....	Nov. 2, 1888
*Poole, Henry Skeffington, A. M., ASSOC., R. S. M., F. G. S., F. R. S. C., CAN. SOC. C. E., HON. MEM. INST. M. E., Guildford, Surrey, England.....	Nov. 11, 1872
Richardson, Prof. Lorne N., Royal Naval College of Canada, Halifax.....	Dec. 9, 1914
*Robb, D. W., Amherst, N. S.....	Mar. 4, 1890
Sexton, Prof. Frederic H., S. B., Director of Technical Education, Halifax.....	Dec. 18, 1903
*Smith, Prof. H. W., B. sc., Agricultural College, Truro, N. S.; Assoc. Memb. Jan. 6, 1890.....	Dec. 1900
*Stewart, John, M. B., C. M., Halifax.....	Jan. 12, 1885
Winfield, James H., Manager Mar. Tel. & Tel. Co., Halifax.....	Dec. 18, 1903
*Yorston, W. G., C. E., Assistant Road Commissioner, Halifax.....	Nov. 12, 1892

ASSOCIATE MEMBERS

Allen, E. Chesley, Yarmouth, N. S.....	Nov. 28, 1913
*Caie, Robert, Yarmouth, N. S.....	Jan. 31, 1890
Connolly, Prof. C. J., PH. D., Univ. of St. Francis Xavier, Antigonish, N. S.....	Nov. 5, 1911
Haley, Prof. Frank R., Acadia College, Wolfville, N. S.....	Nov. 5, 1901
Harlow, L. C., B. sc., Prov. Agricultural College, Truro, N. S.....	Mar. 23, 1905
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S.....	May. 17, 1899
James, C. C., LL. D., C. M. G., Toronto, Ontario.....	Dec. 3, 1896
Jennison, W. F., Truro, N. S.....	May 5, 1903
*Johns, Thomas W., Yarmouth, N. S.....	Nov. 27, 1889
*MacKay, Hector H., M. D., New Glasgow, N. S.....	Feb. 4, 1902
Payzant, E. N., M. D., Wolfville, N. S.....	Apr. 8, 1902
Perry, Prof. Horace Greeley, M. A., Acadia University, Wolfville, N. S.....	May 12, 1913
Pineo, Avard V., LL. B., Kentville, N. S.....	Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton, Annapolis, N. S.....	Jan. 31, 1890

*Life Members.

CORRESPONDING MEMBERS

	<i>Date of Admission</i>
Ami, Henry M., D. SC., F. G. S., F. R. S. C., Geological Survey, Ottawa, Ontario.....	Jan. 2, 1892
Bailey, Prof. L. W., PH. D., LL. D., F. R. S. C., Fredericton, N. B.....	Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S.....	Nov. 29, 1871
Barbour, Capt. J. H., R. A. M. C., F. L. S., care of Holt & Co., 3, Whitehall Place, London, S. W., England.....	Dec. 28, 1911
Bethune, Rev. Charles J. S., M. A., D. C. L., F. R. S. C., Ontario Agricultural College, Guelph, Ontario.....	Dec. 29, 1868
Cox, Prof. Philip, B. SC., PH. D., Fredericton, N. B.....	Dec. 3, 1902
Dobie, W. Henry, M. D., Chester, England.....	Dec. 3, 1897
Fairbault, E. Rodolphe, B. A., B. SC., Geological Survey of Canada, Ottawa; Assoc. Memb. March 6, 1888.....	Dec. 3, 1902
Ganong, Prof. W. F., B. A., PH. D., Smith College, Northampton, Mass., U. S. A. . .	Jan. 6, 1890
Hardy, Maj-General Campbell, R. A., Dover, England, (Sole surviving Foundation Member; originally elected Dec. 26th, 1862, and admitted Jan. 26, 1862).....	Oct. 30, 1903
Matthew, G. F., M. A., D. SC., LL. D., F. R. S. C., St. John, N. B.....	Jan. 6, 1890
Mowbray, Louis L., Hamilton, Bermuda.....	May 3, 1907
Peter, Rev. Brother Junian.....	Dec. 12, 1898
Prest, Walter Henry, M. E., Bedford, N. S.; Assoc. Memb. Nov. 29, 1894.....	Nov. 2, 1900
Prichard, Arthur H. Cooper, Librarian Numismatic Museum, New York, U.S.A. Dec.	4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa . . .	Jan. 5, 1897

Stewart Wallace

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